APRIL 14, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Flow Factors

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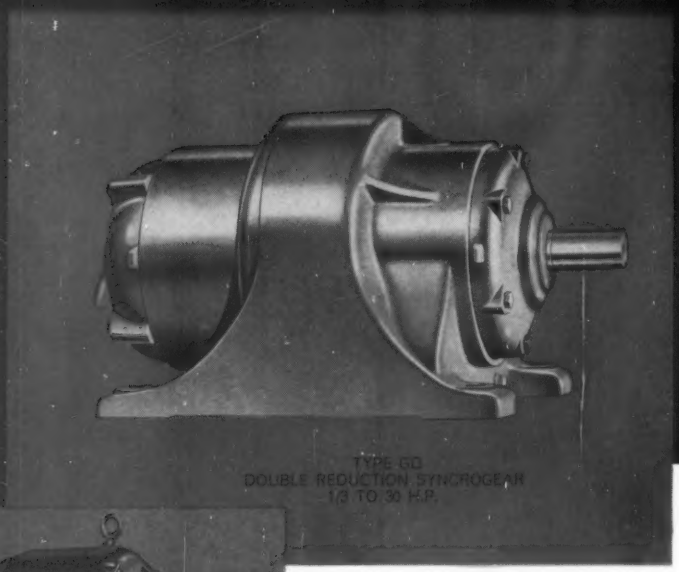
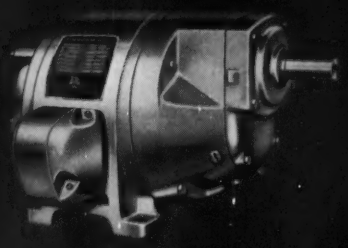
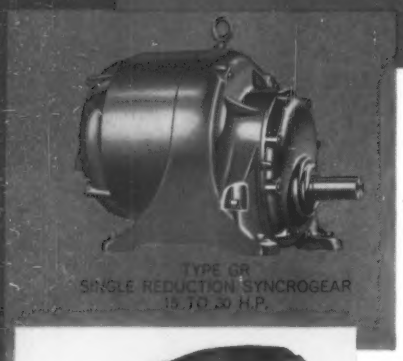


TYPE GD
DOUBLE REDUCTION SYNCROGEAR
1/3 TO 30 H.P.



TYPE GH
SINGLE REDUCTION SYNCROGEAR
1/3 TO 30 H.P.



TYPE GR
SINGLE REDUCTION SYNCROGEAR
15 TO 20 H.P.

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TYPE GW
RIGHT-ANGLE, WORM-GEAR
SYNCROGEAR
1/3 TO 2 H.P.

TYPE GDV
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3 TO 30 H.P.

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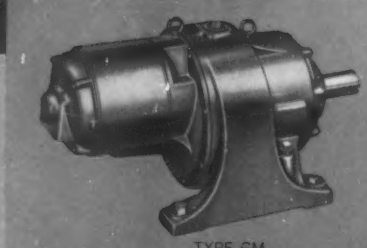
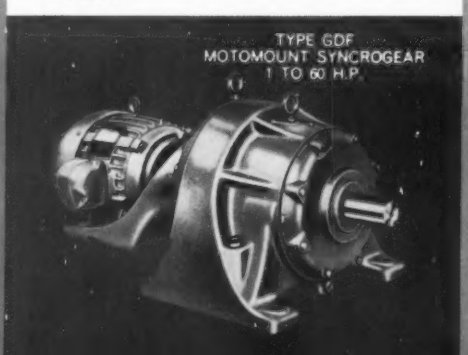
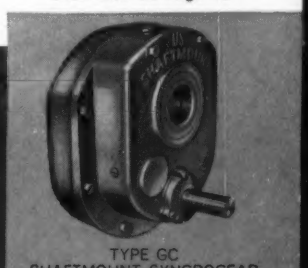


TYPE GM
TRIPLE REDUCTION SYNCROGEAR
1 TO 10 H.P.



TYPE GDF
MOTOMOUNT SYNCROGEAR
1 TO 60 H.P.



TYPE GC
SHAFTMOUNT SYNCROGEAR
1/4 TO 40 H.P.

Gasket engineering

BOLT LENGTH vs. TORQUE RETENTION

Bolt length and bolt torque are important factors in maintaining flange loads on gasketed joints. New engineering studies show the extent of these effects to be greater than anticipated.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

Although retention of bolt torque on gasketed joints can be a function of several factors, two important ones concern the bolt itself: its length and its initial torque load.

Recent tests were conducted at the Armstrong Research and Development Center to establish (1) the relation of bolt length to torque retention; and (2) how torque retention varies with the amount of initial torque involved.

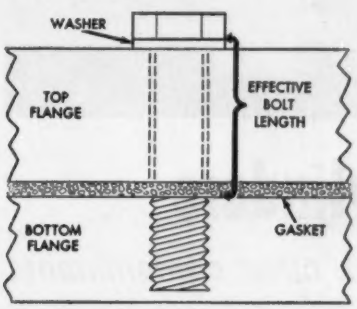


Figure 1. Here bolt length is defined as the distance from the underside of the bolt head to the face of the opposing flange—including compressed gasket thickness and any washer.

In these tests, separate steel flanges were prepared to accommodate three different bolt lengths—½", 1", and 1½". (See Figure 1 for definition of bolt length.) The flanges were gasketed with an Armstrong asbestos material—Accopac AN-890—in 1/32" gauge. The only variables in these tests were bolt length and initial torque values.

After the bolts were torqued to specific loads at room temperature, the flanges were placed in an oven at 300° F. for a period of 18 hours. While the flanges were still hot, the torque was checked again and the percentage of retained torque was figured. Figure 2 shows the results of these tests.

The chart shows clearly that low initial torque loads lose proportionately more torque than higher loads. At 10 ft-lbs. of initial torque, for example, the average torque loss for the three bolt sizes tested was 37%. But at 25 ft-lbs. of initial torque, the average torque loss was only about 8%.

The tests also indicate that longer bolts retain torque better than short bolts. And the higher the initial torque, the more significant the difference in torque retention between short bolts and long bolts.

These results are, of course, what was anticipated in quality. However, in quantity, the difference in torque retention incurred by varying bolt lengths and initial torques was significantly greater than had been expected.

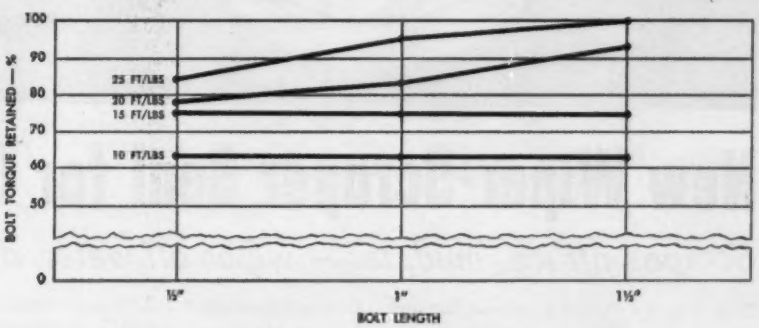


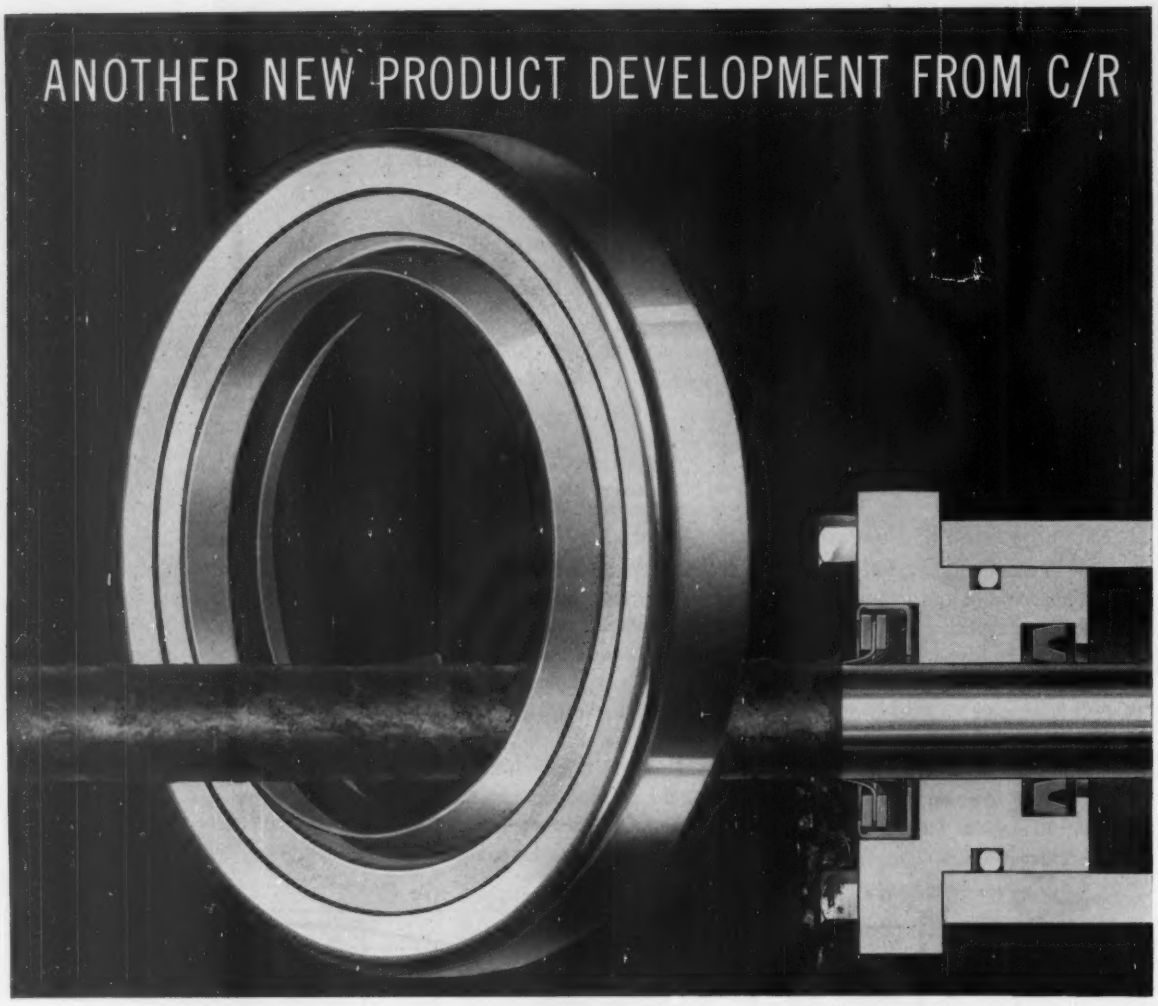
Figure 2. Curves show % of initial torque retained after 18 hours at 300° F. Initial torque is indicated at beginning of each curve. 5/16-24 NF hard steel bolts are used.

In summary, maximum retention of torque is assured primarily by using the longest bolts possible consistent with the design; and by producing maximum elongation in the bolts by torquing them to recommended limits.

The resulting flange loads will usually be well in excess of the seal points of most resilient gaskets.

If you have a specific problem related to torque retention in gasketed joints, we will be glad to make suggestions. Just write to us, giving details of your application. Also, if you'd like a copy of our Gasket Design Manual, write Armstrong Cork Company, Industrial Division, 7104 Dean St., Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS
1860–1960 Beginning our second century of progress



New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

For complete information, specifications and standard sizes, write for your copy of C/R's new Bulletin SC-100

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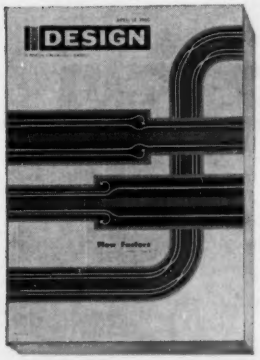
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.



Front Cover: Fluids moving around corners and through passages of varying shape are used by artist George Farnsworth to illustrate common flow conditions. How to predict the pressure losses in these and other design situations is the subject of Gil Riske's article which starts on Page 154.

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Circle 406 on Page 19

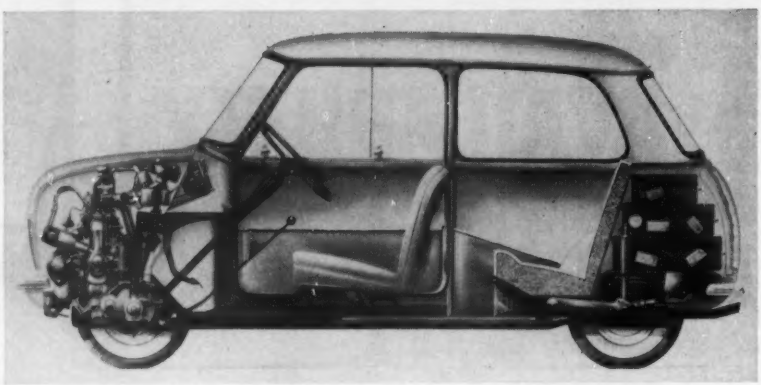
ENGINEERING NEWS

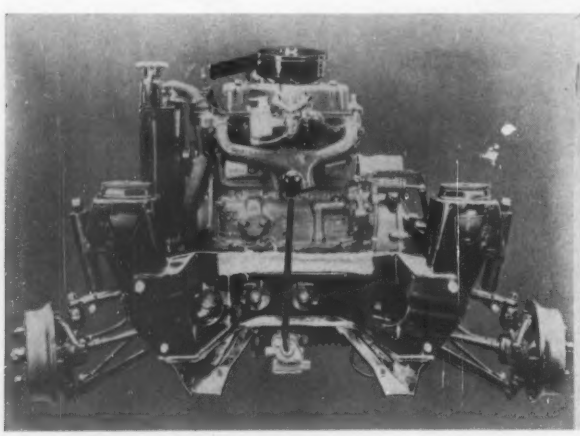
"East-West" Engine Distinguishes New British Economy Car

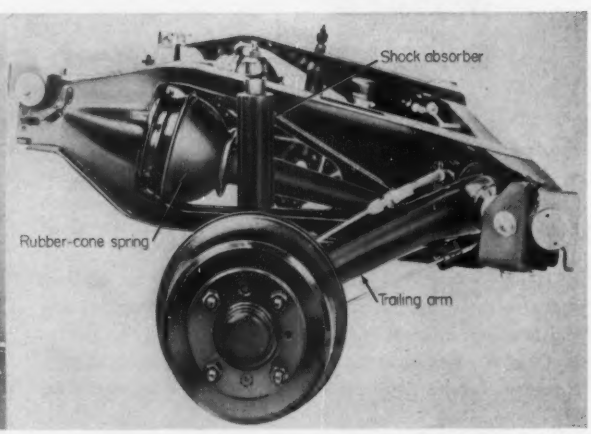
NOT LONG AGO, a German automobile manufacturer introduced a new economy car with the engine mounted in the center. This, for all practical purposes, ended the search for a new and unique place to stow automobile powerplants. Now, apparently, the trick in foreign car-building circles is to change the position of the engine, once the location has been settled on.

British Motor Corp. (MG, Austin, Austin-Healy, Morris, Riley) has narrowed the field down considerably with the introduction of two new models—the Austin 850 and Morris 850 mini-cars. Each model (they are identical except for the grills) has an in-line water cooled four cylinder engine mounted transversely across the front of the frame.

This unusual configuration adds substantially to the cars' "compactness" without compromising the passenger compartment. According to BMC, 80 per cent of Austin/Morris' total length (or 8 out of 10 ft) is made available for passenger use. Front-wheel driven, the cars have a top speed of 75 mph, get a re-







Removable in 20 minutes, the Austin/Morris engine-transmission-suspension package (left) is also the front half of the cars' two-part "frame." Independent front suspension incorporates rubber-cone springs and hydraulic shocks; upper and lower suspension arms swivel on ball joints. Rack and pinion steering is used. Rubber-cone springs, shaped like plumbers friends, are also the key to the cars' independent rear suspension. Horizontally mounted, the springs react to forces transmitted by the trailing arms. Conventional hydraulic shocks dampen the action.

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44 Years of Specializing in Small Gearing!

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ported 50 miles per gallon.

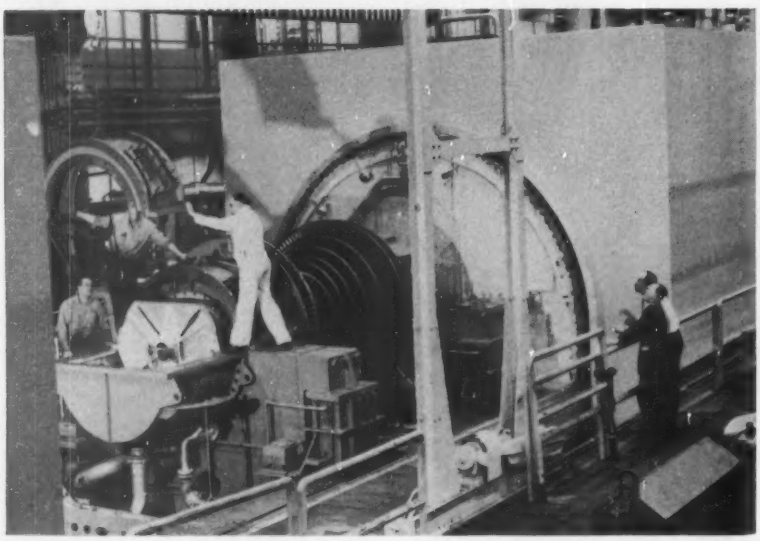
Next to their preoccupation with engine positioning, foreign car designers are apparently most interested in suspension invention. Accordingly, Austin/Morris offers an expected surprise in this category. A few familiar suspension components have been used by the cars' designers, but the over-all layout, in the rear particularly, is entirely unconventional.

A/M's are built in one body style —two-door sedan—and are available with the usual assortment of optional items. Suggested price in the U. S.: About $1300.

"850" Engine Specifications	
Bore & Stroke (in.)	2.48 × 2.69
Displacement (cu in.)	51.79
Compression Ratio	8.3 to 1
Power, max (bhp)	34 @ 5500 rpm
Torque, max (lb-ft)	44 @ 2900 rpm

Dimensions	
Wheelbase (in.)	80
Length (in.)	120
Width (in.)	55.5
Height (in.)	53

Turbine Test Facility



A massive retractable cover, weighing 925 tons, will be trundled over the turbine presently being locked in place at General Electric Co.'s Schenectady, N. Y., test lab. The facility is used for fine balancing of turbine rotors under simulated operating conditions. Turbine blades run at supersonic speeds in a vacuum.

Magnetic Mine Defense—Let Sleeping Mines Lie

MURRAY HILL, N. J.—A more sensitive magnetic flux meter is coming to the rescue of the Navy's Bureau of Weapons in their efforts to protect ships from enemy mines.

Magnetic mines are set off by disturbances in the earth's magnetic field, caused by residual flux in a passing ship. Limiting this disturbance is called degaussing. The Bureau's present method of degaussing has been found inadequate.

The new meter, developed by Daystrom Inc., is the most sensitive yet devised, capable of detecting magnetic forces of 2×10^{-17} watts. It consists of two parts—a cabinet full of instruments, and twelve coils of wire.

The coils of wire are laid on the bottom of a channel or harbor, and ships to be degaussed are run over them. The instruments, meanwhile, pick up and record the changes in the earth's magnetic field—and the degaussing gear on board is adjusted until magnetic variation is eliminated.

Topics

Snugger than a bug in a rug is the householder who walks on carpets having built-in heating elements. Thomas Bond Worth & Sons of Worcestershire, England, is making 9 by 12-ft rugs in several "warm" colors to simultaneously beautify and heat rooms. Elements are woven in at 2-in. intervals. The rug produces 1000 w of heat, which is controlled by a thermostatic plug.

• • •

No more radiator draining, says the Manufacturing Chemists' Association, reporting a new cooling-system fluid. The year-round fluid eliminates the need for antifreeze, water, rust inhibitors, and seasonal draining. It also protects the cooling system against corrosion.

• • •

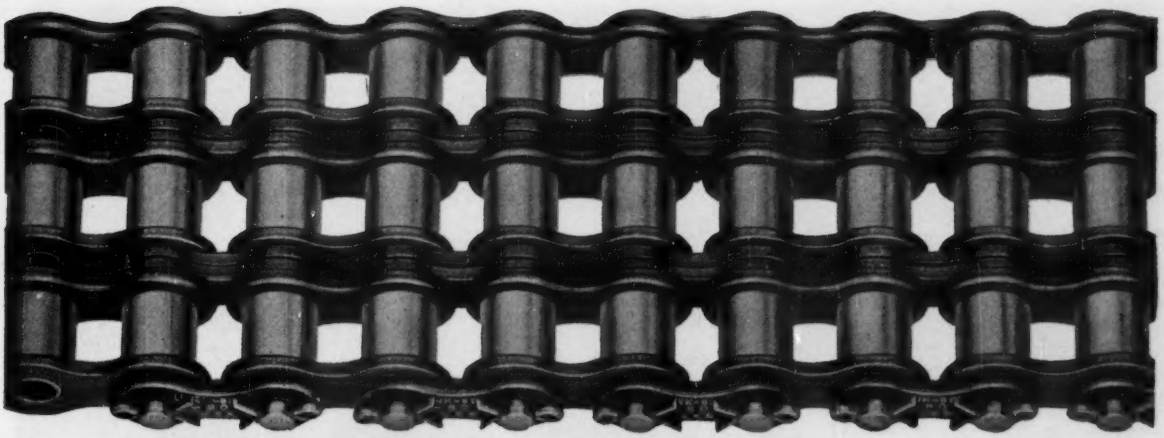
Prospect of being all shook up so far does not appeal to any volunteers for man-in-space experiments. A laboratory machine has been designed to simulate the pronounced vibration and bouncing expected when a space capsule re-enters the earth's atmosphere, but no one has shown any interest in trying it out. Probably one of the Mercury astronauts will take part in the experiment.

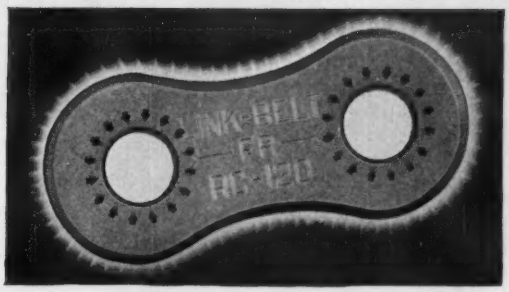
• • •

Warmer wagering will take place at the Maywood Race Track in Chicago during the usually cool early spring and late fall seasons. A heating system using 270 General Electric 3800-w quartz infra-red lamps has been installed to provide approximately 30 w of radiant heat per square foot of seating area. The system will also shed more light on racing literature, providing 70 to 80 foot-candles, which is equal to lighting recommended for schoolrooms.

• • •

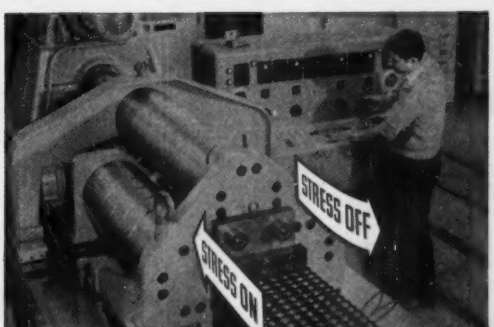
Long drives on the golf course must result from skill of the player, not of the manufacturer of the golf ball, says the U. S. Golf Association, which has spent $40,000 on a machine to measure resiliency. New synthetic rubbers make possible a ball with flight increased by one-third—not a good thing according to USGA, because it would take the skill out of the game and make many golf courses obsolete. The USGA testing machine shoots a ball out of a yard-long barrel and through a 12-in. electronic beam to strike a "club" face. The ball then bounces back through the set of light beams. Speed in each direction is measured and shown on the face of a computer, and ratio of the two speeds is used to calculate resilience.





Arrows indicate critical areas treated with compressive stresses to improve fatigue resistance.

Fortified against fatigue



65 TONS OF CYCLIC TENSION! With this equipment—largest of its kind known to be in operation in roller chain testing—Link-Belt tests and rates roller chains. Rapid "stress-on, stress-off" action duplicates operating conditions at a greatly accelerated pace . . . proving over and over that Link-Belt chains are fortified against fatigue.

Link-Belt offers special FR® processed roller chain for applications involving repeated high-tensile loads

Jobs too rugged for standard roller chains are taken in stride by Link-Belt FR roller chain. Through its patented FR process, Link-Belt gives *greater dynamic strength* to the larger sizes of chain most likely to encounter severe cyclic loading. FR greatly raises the chain's endurance limit by compressing metal around pitch holes—the critical sidebar areas most vulnerable to fatigue failure.

The FR process results from the same design and metallurgical research that has produced many more "extras", all *standard* in Link-Belt roller chains. They include shot-peened rollers, close heat-treat control, lock-type bushings and others. For further details on Link-Belt roller chains, send for Book 2657.

LINK-BELT

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15,060

BOOK 2657 has 154 pages of roller chain data. For your copy, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.)

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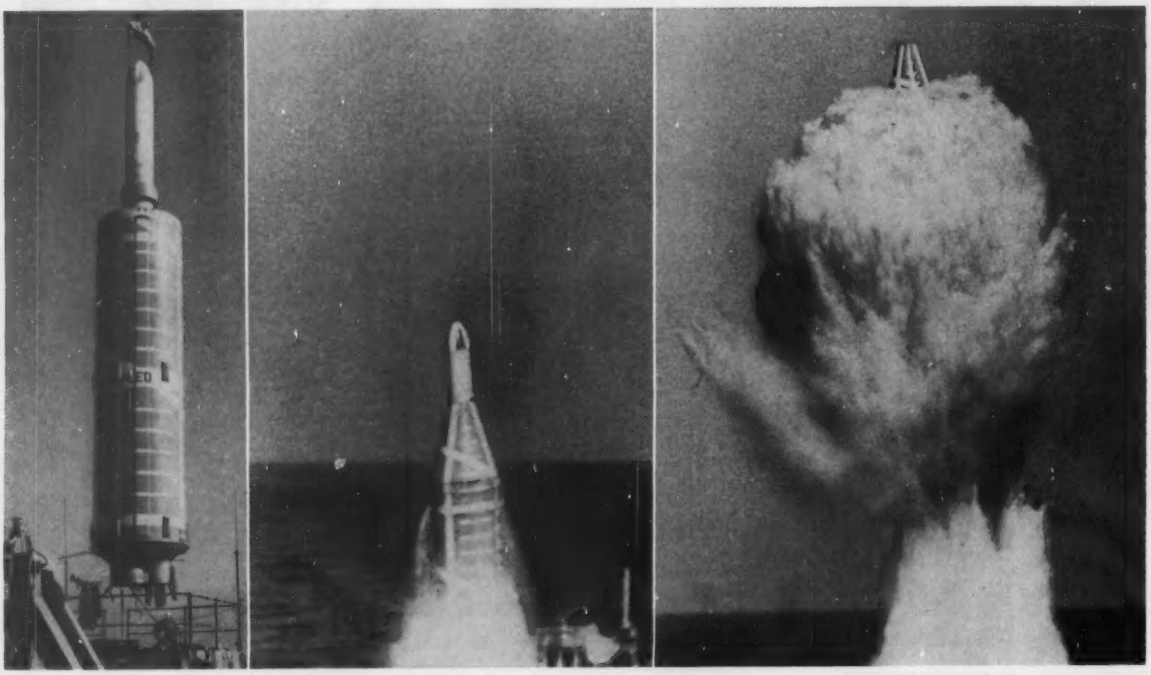
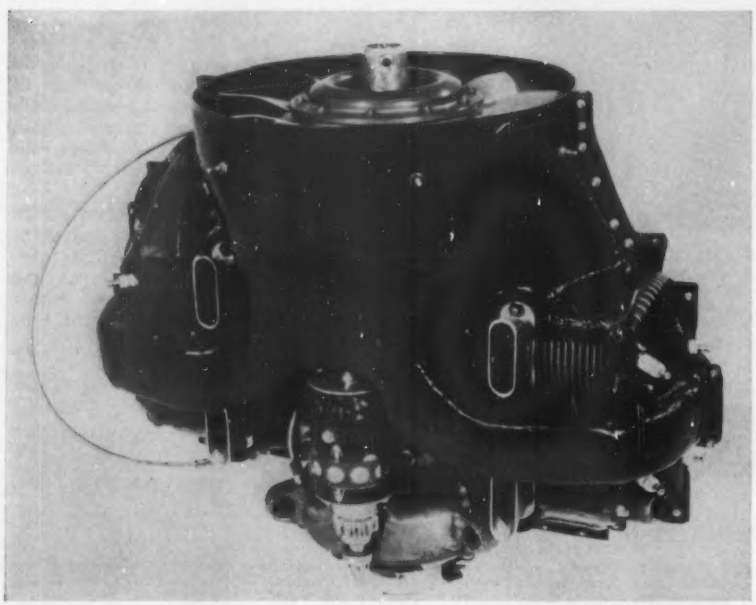
Polaris Preliminaries



Inert Polaris missile carrying half its weight in water will be used to check out all submarine launching systems before adoption of the real thing. In the sequence above, the test missile, nicknamed Dolphin, is lowered into a submersible tube, launched from below the surface, and stopped in its tracks a few feet above surface by the upward ejection of its water ballast. The bouyant missile then floats for retrieval. Its instrument package, mounted in the detachable nose fairing, is carried aloft by the water stream, comes down by parachute. Dolphin is an exact replica of Polaris in size, and accurately simulates all Polaris launch characteristics including weight, center of gravity, and pitch moment of inertia. It will later be used to determine underwater trajectories in sea conditions ranging up to hurricane force. Three Polaris submarines are scheduled to be operational by the end of 1960

Two-Cycle Aircraft Engine Gains Recognition



Two-cycle engine developed for Hiller Aircraft's Rotorcycle (a one-man helicopter) recently became the first of its type to receive certification by the Federal Aviation Agency. Designed by Nelson Specialties, San Leandro, Calif., the 43-hp, 4-cylinder engine package weighs 75 lb, costs "about $5000." It comes equipped with cooling, electrical, and air systems, rubber isolation mounts, and both a normal-flow and an alternate carburetor. The package is designed to be installed in an aircraft in any position.

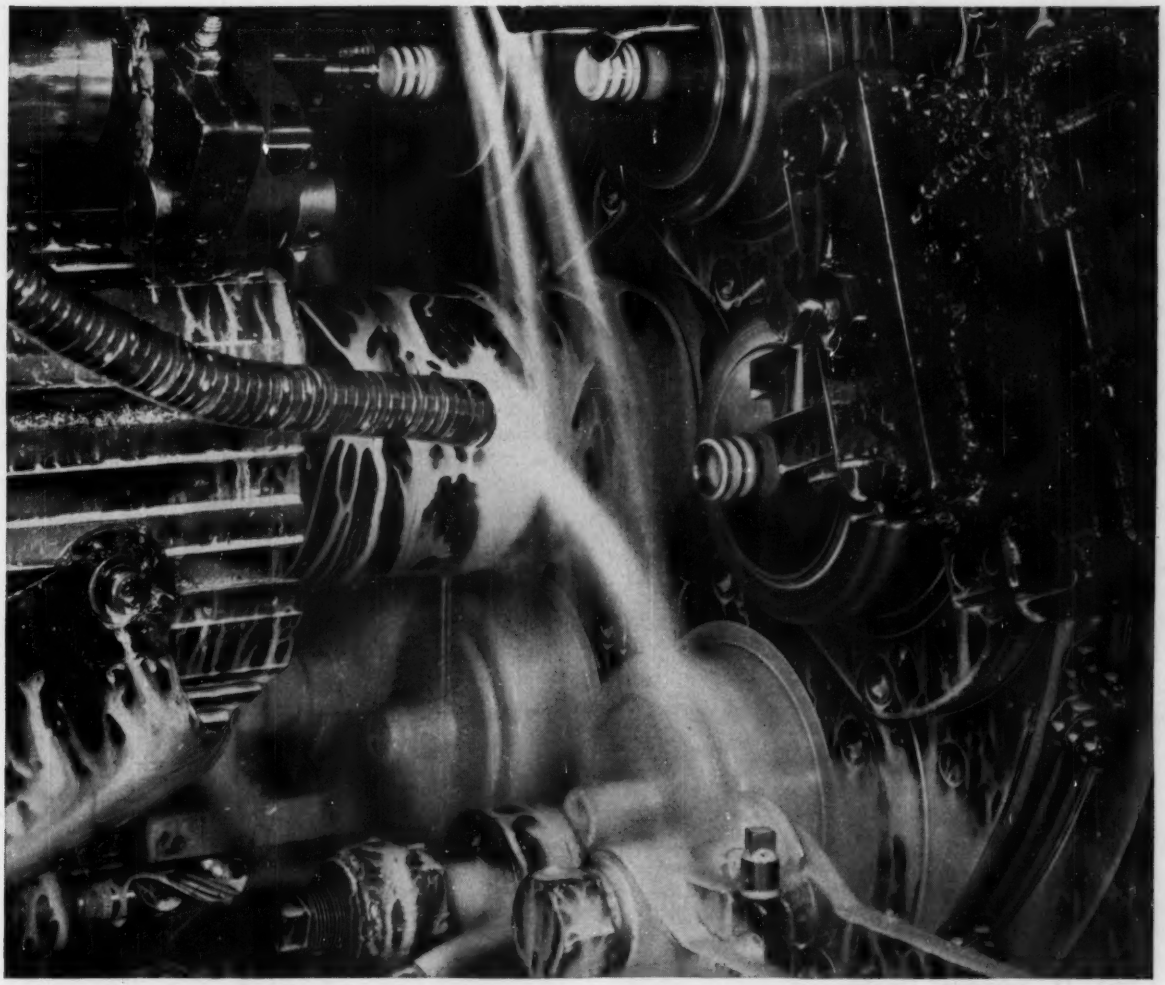
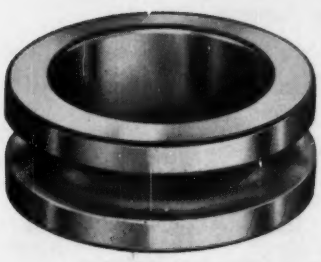


Photo courtesy SKF Industries, Inc.



SKF ... another bearing manufacturer specifies Electric Furnace quality

For critical applications such as anti-friction bearings, SKF requires steel of chemical and structural uniformity and unusual cleanliness. Minimum size and minimum frequency of non-metallic inclusions are also essential.

Aristoloy electric furnace bearing quality steels meet these requirements. Available in types 52100, 4620, 4720, 8620 and 4320, they can be furnished as hot rolled; cold drawn; annealed (spheroidized where required); rough turned; and turned, ground and polished.

For complete information call the Copperweld representative in your nearest large city . . . or write today for NEW PRODUCTS & FACILITIES CATALOG.

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ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

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Design Show Conference Comes to N. Y., May 23-26

NEW YORK—New products and parts —$10 million worth of them—will be unveiled here next month when the Design Engineering Show and Conference takes over all four floors of the Coliseum. Over 400 companies will exhibit their new wares, and over 4000 experts will be on hand to answer questions.

One of the largest expositions ever held in the U. S., the show will run four days—from May 23 through May 26—and will be attended by an estimated 20,000 engineers and engineering managers. Virtually every major manufacturing company in the country will be represented among the visitors; some companies report they will send teams of up to 20 engineers to cover the exhibits.

Research, development, and design engineers charged with planning products will have an opportunity to study virtually every type of component and engineering service they might need. Mechanical components, electrical and electronic components, power - transmission equipment, metallic and nonmetallic materials, fasteners, adhesives, finishes, coatings, etc., will all be available for inspection. About 15,000 products will be shown.

At the same time and place, a four-day conference will be conducted by the Machine Design Division of American Society of Mechanical Engineers. Theme for the conference will be application of space-age design theory and techniques to new products for the home and factory. Speakers will consider advances made in power, control, materials, and computers, and will try to indicate how these advances will influence commercial products.

Conference sessions will begin each day (except Monday) at 9:30 a.m. The Monday session will begin at 9:45, allowing extra time for registration. All sessions will finish in the forenoon, permitting members to attend the show in the afternoon. Schedule is as follows:

Monday, May 23

GENERAL ENGINEERING

New Horizons in Engineering Design

Panel discussion on how design principles, relationships, and formulas developed specifically for nuclear and space technology can be applied to improve commercial products.

William R. Gall, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Varick D. Schwartz, Combustion Engineering Inc., Windsor, Conn.

George P. Sutton, Department of Defense, Washington, D. C.

Elmer P. Wheaton, Douglas Aircraft Co. Inc., Santa Monica, Calif.

Tuesday, May 24

RELIABILITY

Reliability Prediction As a Design Tool

Thomas C. Reeves, RCA Defense Electronic Products Div., New York.

Impact of Reliability on Design

Harry R. Powell, Space Technology Laboratories, Los Angeles, Calif.

FABRICATION

New Welding Processes

John J. Chyle, A. O. Smith Corp., Milwaukee.

Metal Part Fabrication by Explosives

Vasil Philipchuk, National Northern Div., American Potash & Chemical Corp., West Hanover, Mass.

HYDRAULICS

Current Status of Hydraulic Pumps And Some Trends

Edward Brown, Machinery Hydraulic Div., Vickers Inc., Detroit.

Hydraulic Fluids—Today and Tomorrow

Richard L. Leslie, Vickers, Inc., Detroit.

Wednesday, May 25

CONTROL SYSTEMS

Analysis of Control Systems By Analog Computers

William E. Sollecito, General Electric Co., Schenectady, N. Y.

Computers in Control Systems

Dr. Arthur S. Robinson, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

MATERIALS

Some Considerations in the Use Of High-Strength Steels

A. M. Hall, Battelle Memorial Institute, Columbus, Ohio.

Increasing the Performance Of Nonmetallic Structural Materials

W. E. Dirkes, Wright Air Development Center, Wright-Patterson Field, Ohio.

AUTOMATION

Concept of Modular Design For Mechanized Assembly

A. A. Lawson, Melpar Inc., Falls Church, Va.

Basic Design Parameters For Automatic Assembly

Robert Esken, Sheffield Corp., Dayton, Ohio.

Thursday, May 26

GENERAL ENGINEERING

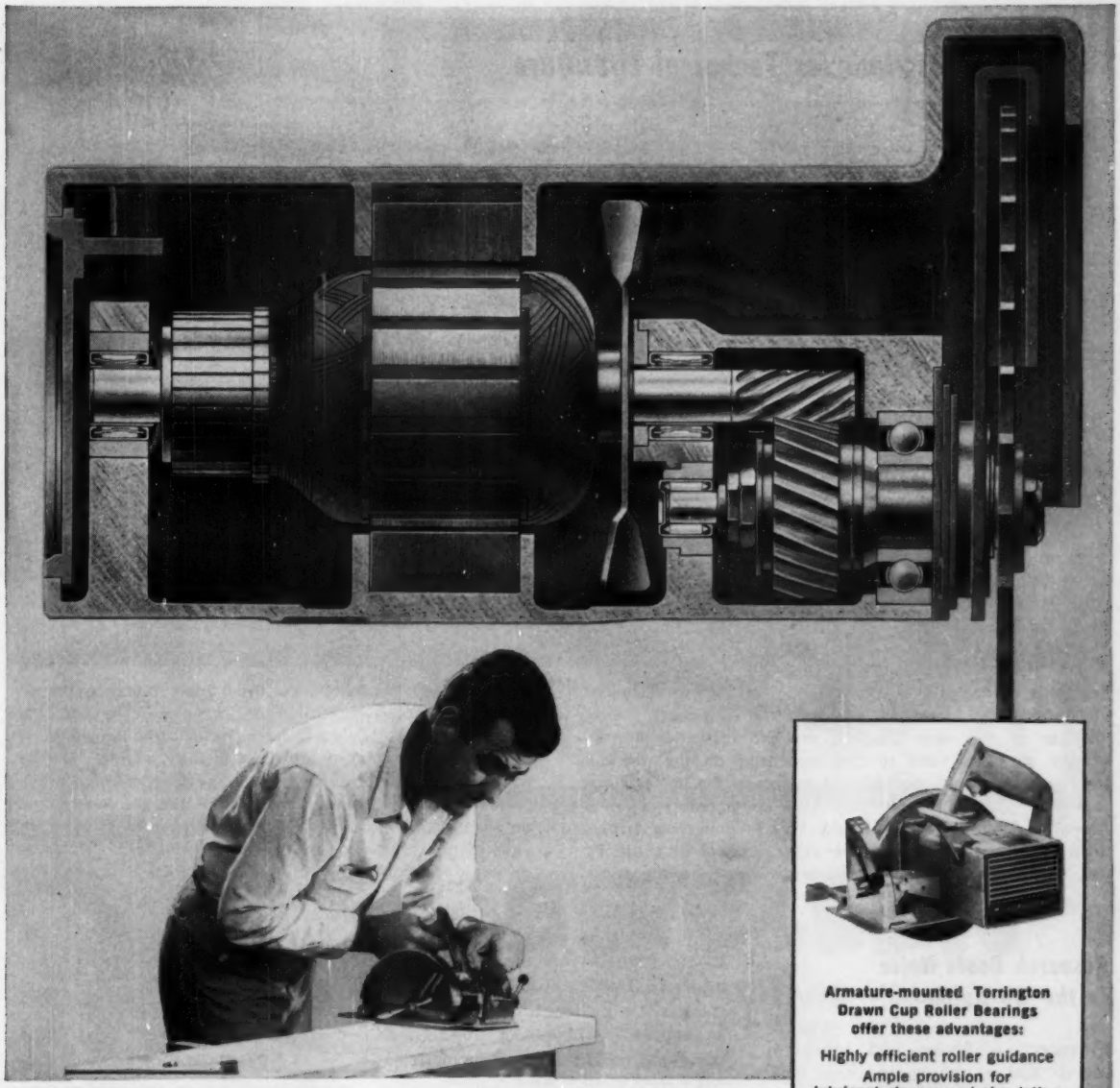
Use of Computers in Design

Panel of users who have integrated computer sections into overall engineering setups will discuss types of design problems that can be computer solved, types of computers to use, training of personnel, and costs of installations and operations.

E. F. Magnusson, General Electric Co., Schenectady, N. Y.

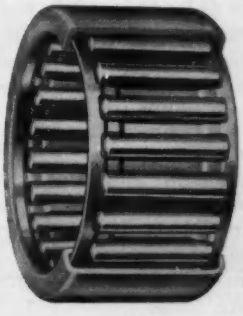
George Ryckman, General Motors Corp., Detroit.

Dr. Aaron Finerman, Republic Aviation Corp., Farmingdale, N. Y.



Armature-mounted Torrington Drawn Cup Roller Bearings offer these advantages:

- Highly efficient roller guidance
- Ample provision for lubricant storage and circulation
- High capacity in small cross section
- Long pre-greased service life
- Outstanding efficiency at high speeds
- Easy mounting by press fit
- Simple housing design
- Low unit cost



Performance plus for power saw armatures with Torrington Drawn Cup Roller Bearings

Armatures of Montgomery Ward's high quality Powr-Kraft Saws are equipped with two Torrington Drawn Cup Roller Bearings for efficient high-speed operation and long pre-greased service life.

The highly effective roller guidance and outstanding lubrication provision are made possible by the one-piece, shaft-riding retainer design of these bearings. The result is added years of extra-smooth starting and cool running.

The drawn cup outer race construction offers outstanding advantages in compactness, light weight, simple straight-bore housing and easy press-fit installation... important factors in high volume power tool and home appliance applications. Yet improved design and construction make these bearings available at remarkably low cost. In many cases, Torrington Drawn Cup Roller Bearings have lowered armature bearing costs by as much as 50%.

Power saws, drills, electric mixers, vacuum cleaners... all types of appliance motors and generators can benefit from the efficiency and low cost of Torrington Drawn Cup Roller Bearings. For advice on specific applications call on Torrington — makers of every basic type of anti-friction bearing.

progress through precision **TORRINGTON BEARINGS**

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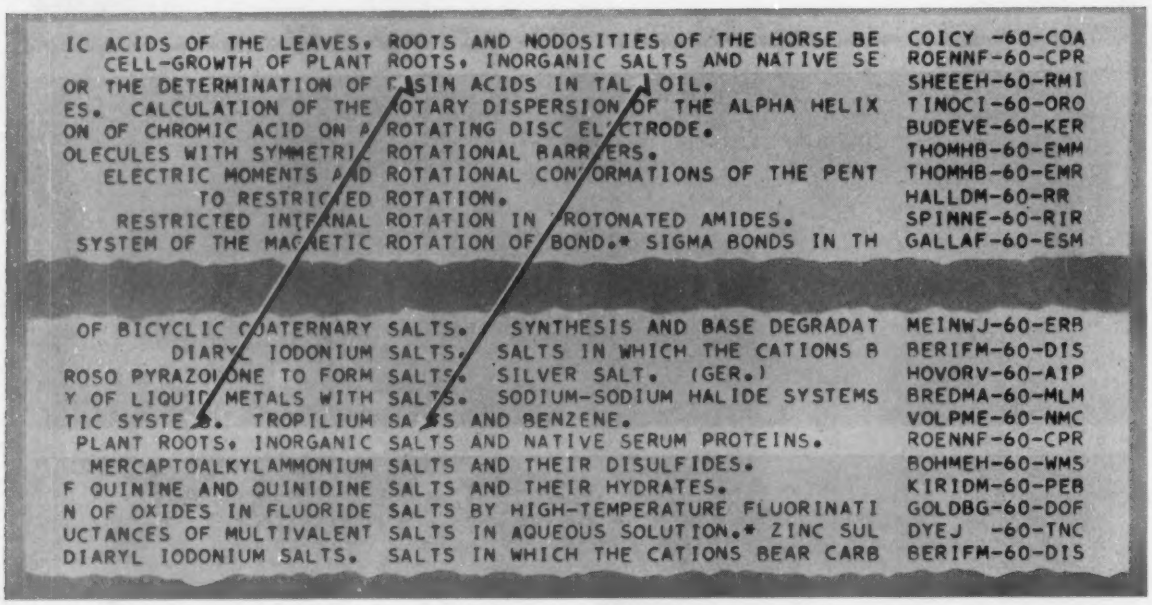
Computer Cross-Indexes Technical Literature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F QUININE AND QUINIDINE SALTS AND THEIR HYDRATES. KIRIDM-60-PEB
N OF OXIDES IN FLUORIDE SALTS BY HIGH-TEMPERATURE FLUORINATI GOLDBG-60-DOF
UCTANCES OF MULTIVALENT SALTS IN AQUEOUS SOLUTION.* ZINC SUL DYEJ -60-TNC
DIARYL IODONIUM SALTS. SALTS IN WHICH THE CATIONS BEAR CARB BERIFM-60-DIS

Electronic editors are now speeding the flow of technical information to America's scientists and engineers. One member of this new breed is an IBM computer that is trained to cross-index articles appearing in the world's leading chemical journals almost as fast as the journals are received. (The index is published semimonthly by the American Chemical Society, New York.) Connecting arrows drawn from two pages of the index (above) illustrate its use. In the example, two entries referring to the same article appear in alphabetical order (determined by the key worlds "roots" and "salts" respectively). The computer has "sliced out" 60 letters from the article's title, and has determined which words are keys to the contents. The key words are then positioned in the center column of the page for quick scanning. The right-hand column contains an identification code made up of the author's name, the year of publication, and the title. Identification codes are arranged alphabetically in the bibliography section.

Research Beats Noise In the '60 Autos

DETROIT — Noise and vibration never had a chance in their 1960 cars, according to Chrysler Corp. The culprits were designed out before the cars were even built.

Although Chrysler engineers have studied auto-noise problems for years, they started their new study at the beginning, with a look at the physical characteristics of sound —such as loudness, pitch, and quality—and then graduated into a detailed study of car noises and their causes. They attacked the problem from six angles:

- Reduction of noise at its source.
- Isolation of vibrations.
- Reduction of vibration intensity.
- Cancellation of sound by resonant tuning.
- Isolation of auto noise from airborne noise.
- Absorption of noise.

Research tools—including an electronic highway, shake and shake-analysis equipment, and special dynamometer facilities—were designed to scrutinize all types of engine and driveload conditions independent of road conditions. And modern computer techniques were used to construct a mathematical model of a car, reducing the baffling complexity of sound in an automobile to orderly mathematical terms. With the mathematical model, engineers evaluated countless designs by simply manipulating numbers and solving equations.

Changes in the 1960 Chrysler Corp. autos due to the research findings include features such as Unibody construction, tuned engine mounts, the keyhole firewall grommet, the new sound blanket, and front and rear suspension isolation. Spokesmen claim they have gained a whole new design philosophy in the world of noise and they report that the study of silence is now a science. Even "higher quietness" is promised in future cars.

Canned Messages Viewed By Pilots

LYNCHBURG, VA.—Messages will be displayed visually in a new communication system being developed for the Air Force. The system combines audio and visual facilities so that both air and ground crews have the option of conversing by either method.

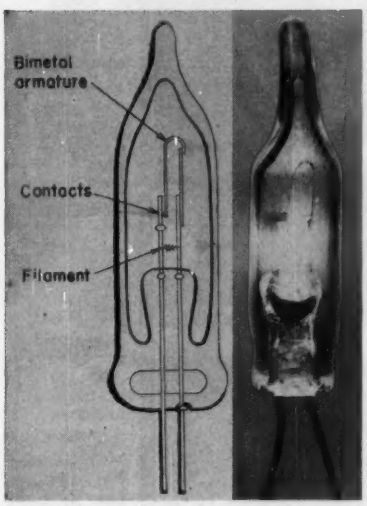
If voice transmission is to be used, the headphone-microphone in the plane is switched on remotely, from the ground station. When visual messages are to be used, the ground station feeds a four-letter call signal into the memory of a digital computer. A modulation adapter converts the binary impulses into FSK (frequency shift keying) tones that are broadcast on very narrow bandwidths at high speed. Automatic equipment in the plane responds, and a light on the instrument panel flashes. Next, the call sign of the ground station appears on the message screen, followed by the message,

usually consisting of alpha-numeric symbols, or code letters.

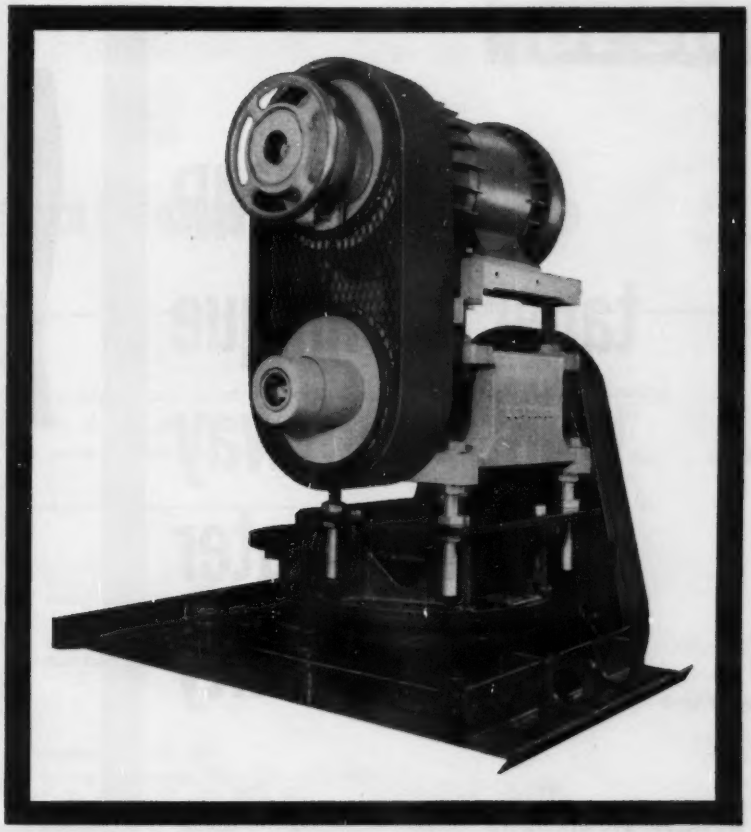
Principal advantages of DISCOM, developed by the General Electric Co., is that it permits fixed format messages to be stored in the computer memory. Thus, the pilot, to reply to a ground-air communication, need merely press a button marked "Acknowledgment." The computer would take care of relaying this message to the ground station. Similarly, he may have at hand a number of fixed messages, such as "send landing instructions," "plane in distress," etc., without having to devote attention to the transmitter.

The time required to establish contact is about five seconds, and selective calling of specific groups or individuals may be accomplished, as well as general broadcasts to all planes. This points up a secondary advantage of the system. Since communications are made selectively, pilots receive only messages intended for them.

Short Circuit Reminder



An indicator light in this remote-reset circuit breaker flashes on when an overload occurs. Heat from the filament then holds the circuit open until the overload is removed. External heat (200 F) also trips the device. Resetting time, at 78 F, ranges from 5 to 40 seconds. Developed by Sylvania Lighting Products, Salem, Mass., the new breaker is 1¼ in. long by ¼ in. in diameter. It operates at 6 to 24 volts ac/dc and is available in a range that holds from 1 to 5 amp; trips at double the emperage. First applications: Computers and automobiles.



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COMPONENTS PACKAGE YOUR VARIABLE SPEED DRIVE

Standard LEWELLEN components assemble with your motor for a compact variable speed unit.

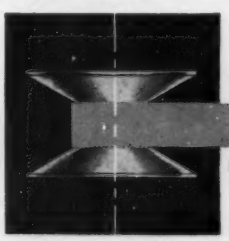
Here is all the convenience of a packaged drive, ready to connect to your equipment—at a reasonable cost.

LEWELLEN Variable Speed Pulleys offer finely graduated speed adjustments over wide speed ranges, with excellent horsepower characteristics, plus overload capacity.

LEWELLEN Pulleys present no problems. Just the two shafts mount the pair of pulleys shown. Shaft and bearing loads are normal. No thrust loads are imposed.

The performance you may expect, as well as the convenience and utility of LEWELLEN Variable Speed Pulleys is explained in Catalog 70.

Are you interested?



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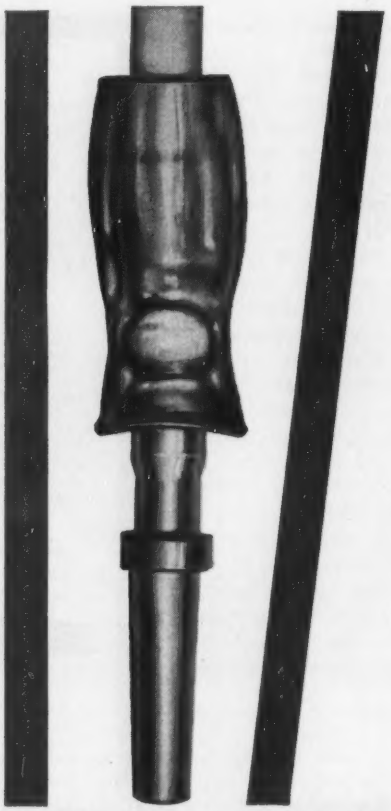
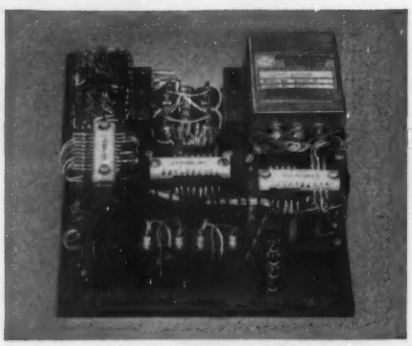
AMP taper technique points the way to greater reliability



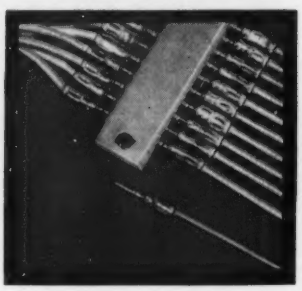
Magnetic Amplifiers, Inc. of New York carefully manufactures its Static Inverters with a step-by-step quality control and testing program to build in the reliability required for aircraft and missile applications.

It found that AMP Taper Technique simplified this procedure. A high speed AMP Automachine pre-terminates circuit leads with crimp-type, pre-insulated solid Taper Pins. Components are then easily tested in the modular stage before final assembly. Crimping eliminates difficult soldering operations and the danger of burning wound components while Taper Technique permits checking and trouble shooting without destroying the main cable. After final assembly, when the Pins are inserted into the Blocks, this Technique provides rugged vibration resistance and operational reliability.

AMP solderless Taper Pins are made in formed and solid types, with or without pre-insulation and mate with a wide range of one or two piece stackable Taper Blocks. You'll find that AMP Taper Technique is ideal for *your* quality control or circuit density problems too.



Magnetic Amplifiers' 250VA Static Inverter Model SIS-425041



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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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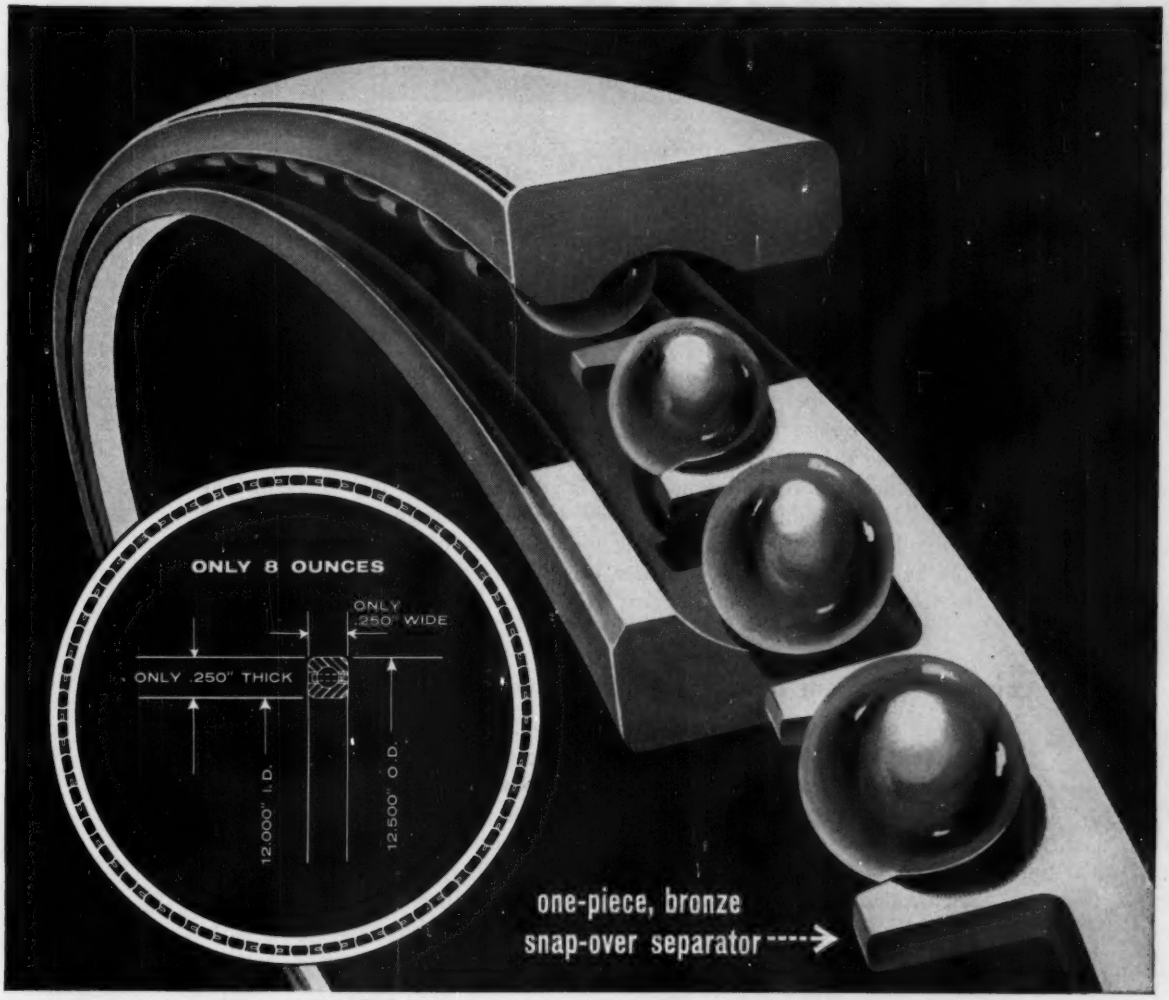

News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

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Circle 413 on Page 19

design help for wash-day blues

Consumer skepticism may die hard, but home-appliance manufacturers seem to be intensifying efforts to improve ruggedness and serviceability in the next washer-dryer-refrigerator generation. To cut warranty woes, for example, Maytag is emphasizing a design-simplification program on its automatic washers. A 30 per cent reduction in the number of parts has enabled the company to raise the transmission-warranty period from one year to five years. Like Kelvinator, Maytag is also cutting out yearly model changes, will market new models only when there is genuine product improvement. Purpose of the industry program, say industrial designers, Lippencott & Margulies, is to check skyrocketing complaints by customers burned in the '50s by inferior quality, poor service, expensive repairs, and hastily-introduced models face lifted with meaningless chrome and frills.

current problem in space flight: how fast?

Before man can rocket off to Mars, he will need a simple, reliable space speedometer. But would-be inventors are cautioned that design of the instrument won't be an easy project. In a report on navigational needs for interplanetary space flight, W. R. DeHart, head of the Countermeasures Dept. at University of Michigan's Willow Run Laboratories explains that in the vacuum of outer space the traditional media for monitoring speed (drive shafts, air, water) are lacking. Something entirely new is needed. He notes that all other navigational aids required for a successful Mars flight can be refined from existing instruments.

wanted: graduates with computer training

College students planning to enter industry should be trained in the use of computers, according to 325 companies surveyed by Pennsylvania State University. More than 70 per cent of the companies surveyed have computer facilities and indicate a definite preference for graduates with computer training. When asked which curriculums should include computer courses, the companies listed their preferences in this order: Mathematics, accounting, electrical engineering, business administration, mechanical engineering, chemical engineering, and physics. The companies also reported that they have 1031 unfilled computer jobs now, will have at least 4000 more by 1970.

Atlas keeps growing

A range of more than 10,000 miles is expected from the Convair Atlas-E intercontinental missile, the model that will follow the current D-series in test firings at the Atlantic Missile Range. Nominal range for the Atlas under original planning was just 5500 nautical miles, or 6325 statute miles. Total thrust of the Rocketdyne engines powering the big ICBM has been boosted from 360,000 lb to a planned 402,000 lb for the E-series. Other gains in range have been achieved by switching from corrugated metal to a glass-fiber skirt around the two booster engines, by decreasing the weight of avionic equipment, and by shifting engine-system components from scattered locations in the missile to locations nearer the engines themselves.

AF initiates research on thinking machines

Studies in bionics—the simulation of superior biological capabilities demonstrated by animals—should be an immediate objective in electronics research, according to a spokesman for the Air Force. Col. W. S. Heavner, chief of Wright Air Development Division's Electronic Technology Lab., told a recent IRE session that classical biological phenomena such as bat navigation, bird homing, and human servo-mechanism activities, including learning and thinking, are definitely in the realm of electronics research. He noted that WADD is already sponsoring research aimed at synthesizing the neuron. "Scientists have reasoned what a neuron must be capable of performing, and from this analysis a synthetic neuron is now being developed by researchers at General Electric Company under Air Force sponsorship." The ultimate objective, according to Col. Heavner, is the connection of a large number of artificial neurons into a network which will perform at least some of the functions of the human brain.

paste-up cars

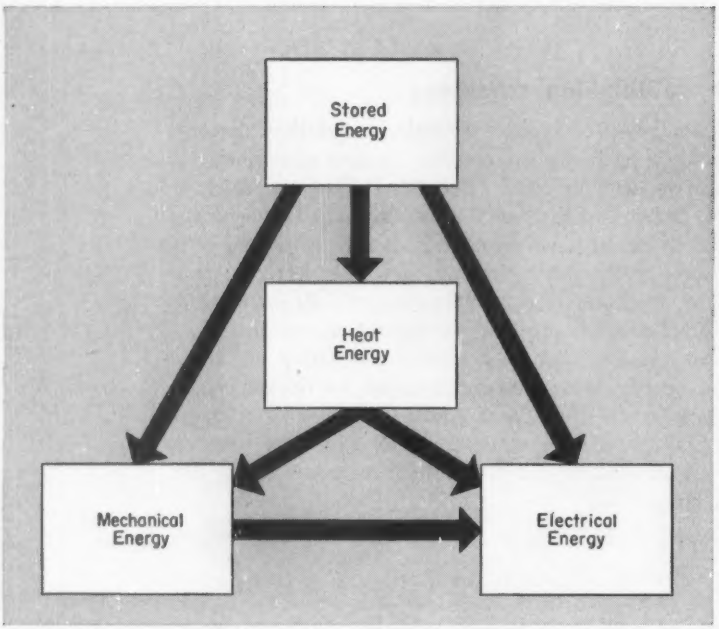
Growing use of nonferrous metals in automobiles will be accompanied by a similar gain in the use of adhesives for fabrication. This prediction was made by A. F. Thomson and A. F. Martin of Minnesota Mining & Mfg. Co.'s Adhesives Coatings and Sealers Div. The 3M men listed a number of important advantages that can be expected when adhesives make their debut: Use of lighter gage metals will be permissible since the load can be spread over a larger joining area; joining dissimilar metals will be accomplished without the hazard of galvanic action; and, perhaps most importantly, adhesives form a seal as well as a bond. Exterior coach joint headaches will become a thing of the past. They visualize a unitized top in which the present stiffeners, insulation pads, and headlining are replaced by a structurally bonded honeycomb. The two men even included powerplants in their paste-up predictions. They stated that certain engine components "have been created using adhesives which have given performance in excess of present designs."

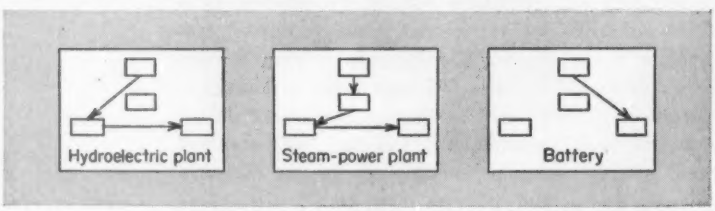
hard road ahead for ground-effect vehicles

In its quest for full aerial mobility, the Army recently turned its full attention to ground-effect vehicles. A vast number of these machines are in various stages of development in this country and abroad, and a few have actually "flown." According to one expert in the field, however, the entire concept should be dropped—at least by the Army. J. B. Nichols, manager of Hiller Aircraft's Advanced Planning Dept., told a recent SAE aeronautic meeting that, "Ground effect machines are ground-bound machines, sharing all the penalties of the wheeled vehicle but not sharing its primary asset—ground friction—which allows the wheeled vehicle to climb hills, make turns and stop under full control. No amount of propulsion-system improvement will overcome this basic inadequacy of ground-effect machines, particularly for land operations. Even the over-water applications are questionable. And when the impact of this fact finally hits its mark, GEMs will meet a natural death." According to Nichols, the Army should stick to helicopters.

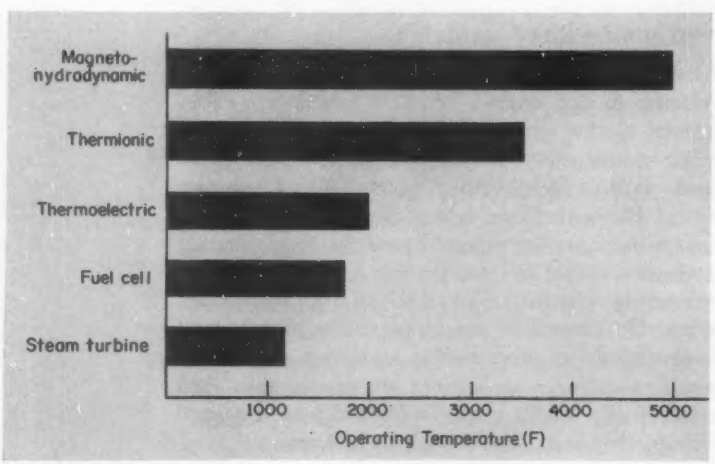
POWER . . . *without moving parts*

In hydroelectric and steam plants, turbines and other rotating hardware waste energy. These conventional systems detour energy stored in a fuel into mechanical form before converting it to electricity. But conversion is more direct in a new breed of generators now under development. Like batteries, they have no moving parts. Although today they are primarily of interest to the military, Westinghouse researchers predicted at a recent technical seminar that these new generators will soon find civilian jobs.





Experts agree that if the new power sources are to produce sizable chunks of electric power (central power-station plants), they will have to operate at high temperatures. The most modern steam-powerplants are limited to operation at about 1200 F. At higher temperatures, parts fail or wear out too fast. But the new plants won't face the same limitations because they won't require physical strength from ceramics and other materials that can withstand high-temperature operation. The advantage of no moving parts removes dynamic limitations from high temperature operation, and the devices will be limited only by materials.



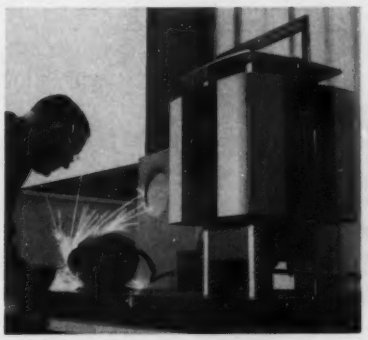
FUEL CELLS, thermoelectric, thermionic and magnetohydrodynamic generators—and "one or two sleepers"—offer some major advantages. They have no moving parts and, for this reason, they're inherently more efficient and more reliable than conventional powerplants. Unlike their contemporary cousins, they can be made to operate efficiently in small or large sizes. They may compete with everything from small portable gasoline engines to huge central-station generators.

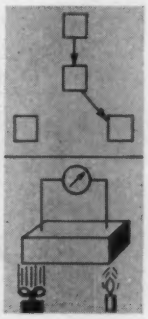
Why All the Interest?

Since the turn of the century, reports Dr. S. W. Herwald, Westinghouse vice president in charge of research, the population of the U. S. has about doubled, but use of electricity doubles every decade. In 1959, electric companies produced over 700 billion kilowatt hours and the upward spiral is expected to continue. The experts—even the optimistic experts—say that the supply of conventional fuels will run out within the next 100 years.

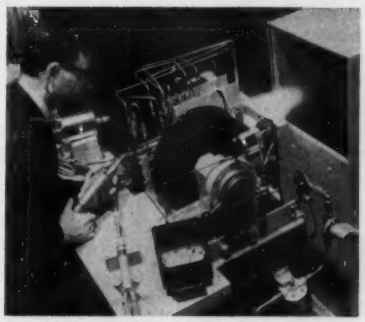
Today there is a quest for new prime sources. Fission, fusion, solar power, and other energy stores are being tapped to provide usable power. But we must also find ways to exploit these new sources and to

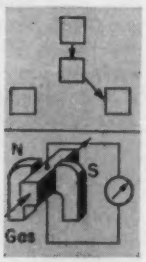
Thermoelectric devices, the most familiar of the new breed because of their long application in temperature measurement, depend on one end of a pellet being heated, the other end cooled (or at least not heated). Electrons travel toward the cool end, then return to the hot end via an electric circuit. In actual use, the pellets are arranged in an array of series-connected thermocouples, formulated so that voltages are additive. Portable generator (right) is a convection, air-cooled device that burns propane as a fuel, produces 100 watts electrical output.



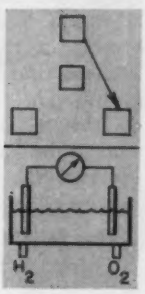


Magnetohydrodynamic generators take advantage of a well-known phenomena in a new way: When a conductor moves in a magnetic field, a current is generated in that conductor. But instead of using a copper bar or wire, MHD generators put fluids to work. The most practical fluids seem to be ionized gases, and the most direct approach is to ionize the gases by heating them to high temperatures. When the gas is "seeded" with potassium or cesium, adequate electrical conductivity can be obtained at temperatures in the 4000-5000 F range. As the gas travels through the magnetic field (at right angles to the flow) electrons, deflected by the field, make their way diagonally to the anode.

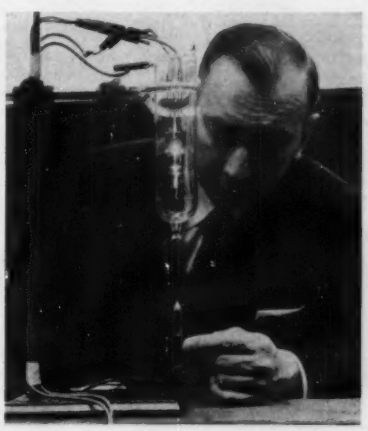


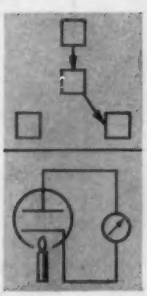


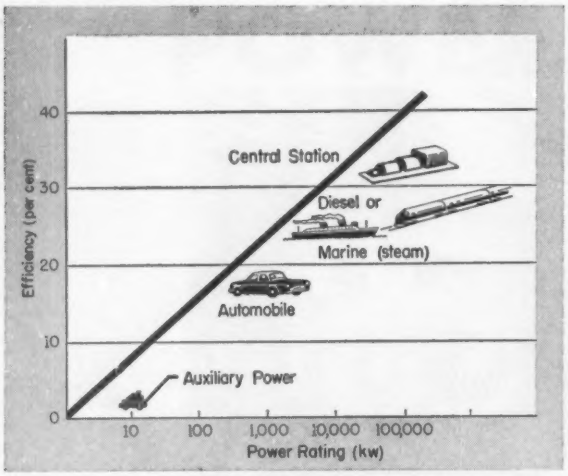
Fuel cells convert the free energy of a chemical reaction directly to electrical energy. The fuel is ionized at the cathode and ions travel through the electrotype to the anode where they react with an oxidant. Electrons liberated return to the cathode through the external circuit. Experimental models of high-temperature fuel cells seem big (right) because the size of the furnace and containers overshadows the fuel cell itself. But the furnace can be made a negligible part of a large-power system, and heat generated by the system could sustain the reaction. Because the cell converts directly from stored to electrical energy, it's potentially the most efficient power generator conceived.

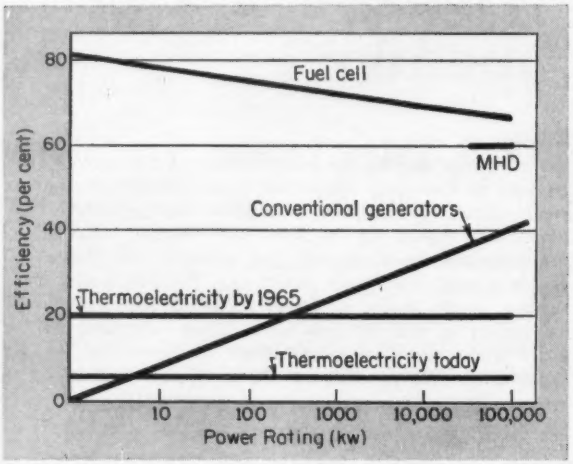


Thermionic generators need high temperatures. Electrons are boiled off one of two plates, picked up by the other. The electrons then return to the first plate through external wiring. Operating temperatures limit efficiency, and, in turn, are limited by materials able to withstand high heat. Current densities must be high; while heat radiation losses increase with temperature, they do not increase nearly as fast as current. Factors that will determine the feasibility of thermionic devices are work functions of anode and cathode, electron emission constants, and radiant emissivities. Major needs are for suitable cathode materials with very high melting points and very low evaporation rates.









Only the largest conventional heat engines operate efficiently (left). And even these leave a lot to be desired. The new breed of power generators is potentially better in every size (right). Thermoelectric devices today can compete with conventional engines rated up to about 10 kw; if projected improvements materialize, by 1965 this type of generator will compete in sizes up to 1000 kw—and will be vastly superior in small sizes. Fuel cells are potentially the most efficient of all the energy-converting devices. They seem sure to inherit much of the power-generation work once technology has solved materials problems associated with high-temperature operation.

more effectively extend the earth's diminishing fuel supply, Dr. Herwald continues.

Power for space gave this conversion program a tremendous shot in the arm. Small, reliable, self-contained electric powerplants are a space essential. And here on earth they will find more uses as they become increasingly sophisticated. Perhaps the first unconventional central power station will be built on the moon, but this does not change the fact that eventually unconventional power stations must also be built on earth.

Where Do We Stand Today?

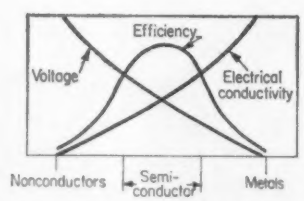
Thermoelectric generators can now compete with the smallest conventional powerplants because the latter are very inefficient. And in the future, fuel cells and thermionic devices will also compete, at least in special applications where their particular characteristics become advantages. For example, fuel cells are rugged, yet operate silently; they seem a natural as portable powerpacks for the military.

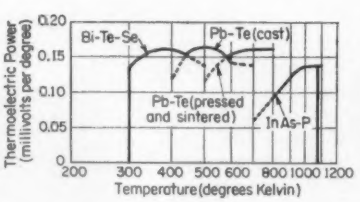
Efficiency of contemporary equipment is directly proportional to size, and only the large generators can lay any real claim to efficiency (about 40 per cent). But in the new breed, efficiency is generally independent of size. When the new types become competitive with large-scale generators they will truly have arrived.

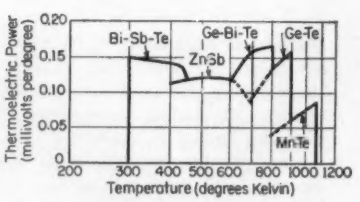
Breakthroughs Are Needed:

Before this can happen, breakthroughs in materials research are needed. It's taken 50 years of research and development to bring operating temperatures of steam turbines up to 1200 F, but none of the new devices will generate economical power at temperatures this low. Fuel cells operate over a wide range of temperatures, but those that use low-cost fuels will probably require 1800 F. This doesn't mean that cells using an expensive, refined fuel won't be useful—they

Key to Progress: Better Materials







Power produced by thermoelectric materials depends on both the output voltage generated and on conductivity (left). Both of these factors, in turn, depend on the number of free electrons in the material. Metals don't work well because voltages are too low. Nonconductors don't work either because conductivities are too low. Maximum power requires semiconductors—a compromise between the two factors. Calculations show that the best thermoelectric materials should have a free-electron density of about 10^{19} per cc (compared with 10^{10} for insulators and 10^{22} for metals). Many such materials can be formulated, but each has optimum properties only over a limited range of temperatures (center—hot-junction materials, right—cold-junction materials).

will. Fuel cells are inherently the highest efficiency conversion systems. But fuel cells will not generate economical "chunks" of power until high-temperature, low-cost electrodes and electrolytes can be developed to successfully resist corrosion for long periods of time.

Thermoelectric generators also present materials problems. Today, thermoelectric materials convert heat to electricity with an efficiency of about 17 per cent, but thermoelectric devices are only about 6 per cent over-all efficient—due to factors like flue loss. In five years, these figures should be substantially improved, eventually reaching 30 per cent or higher.

Thermoelectric generators for large-scale power will probably operate near 2000 F, but this is still a long way off. However, we are on our way toward practical thermoelectric devices that can perhaps do the job of medium-size powerplants, says Dr. J. A. Hutcheson, Westinghouse's vice president of engineering.

Thermionic generators get into real materials problems. To generate 100 megawatts, a 10,000 sq ft cathode operating at 3500 F would be needed. And the cathode would have to operate in a high vacuum over its entire area.

MHD generators are even hotter. A 100-megawatt generator would have to maintain temperatures of 5000 F within a space 3-ft diam by 60 ft long. Inside this space, ionized gas would have to move at about three times the speed of sound.

Forecast for Tomorrow:

Large-scale generators have not yet arrived, but research may make them possible in coming years. Their future is not as bleak as it might seem for several reasons:

- Efficiencies are high. Fuel cells have an efficiency of 90 per cent, and 75 per cent seems a likely value for a successful cell. MHD systems appear to fall in the 60 per cent over-all efficiency region. Thermionic efficiencies are of the same order as thermoelectric efficiencies.
- Direct conversion methods may be quite reasonable in capital cost.
- Unique characteristics of the generators might give rise to new concepts of power generation in a wide range of output ratings.

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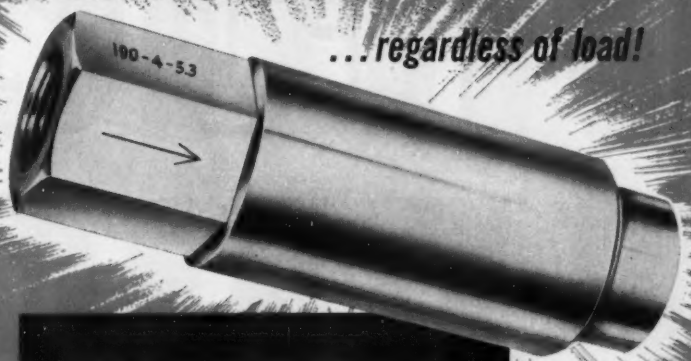

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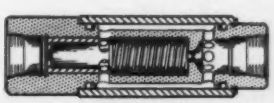

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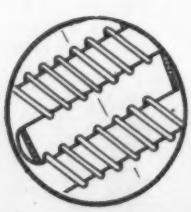

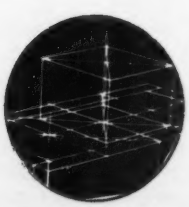

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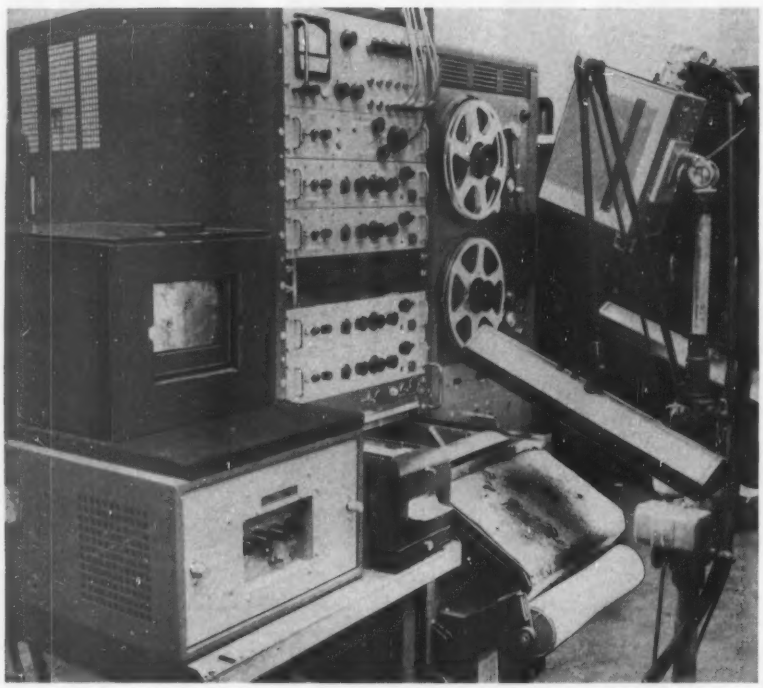
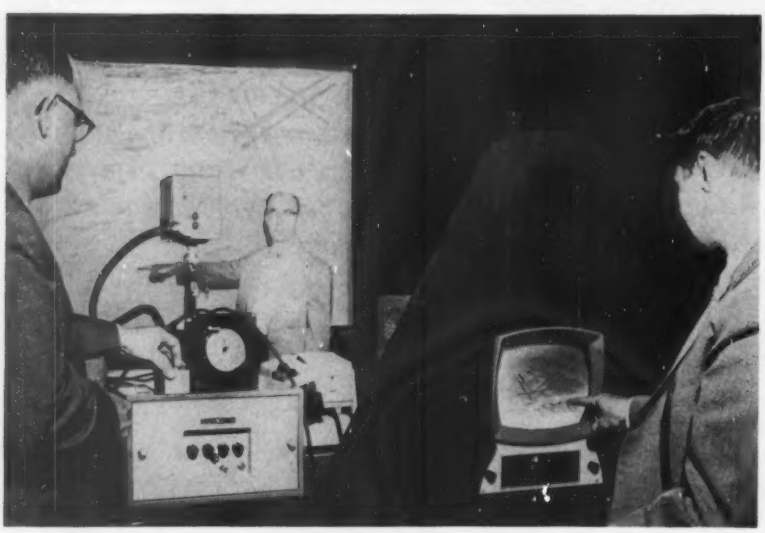
Poor Man's Simulator



Rolling landscape, as it would appear on the scope in an aircraft cockpit, is easily "picked up" in the laboratory by means of a strip-map transport and tv camera (above). This technique simulates, quickly and inexpensively, the same sort of display that would be produced by full-scale radar or infrared surveillance equipment. A 35-mm slide projector (below) can also be used to supply a realistic input to the display. With further additions to the equipment, the mock-up can be made to respond to one or more controls.



THE EXTREME COMPLEXITY of today's aircraft and tomorrow's space vehicles requires, for the pilot's benefit, simple instrumentation. The trend in navigational and surveillance devices, for example, has been toward large visual displays that give the pilot a picture of both the terrain below and the path his aircraft (or capsule) is traveling.

Much of the development work on these displays is carried out under the direction of human-factors engineers and they are invariably faced with two traditional handicaps: Shortage of time and money; i.e., most of the effort in any major project is directed at developing black boxes that supply input to displays.

Although it is possible to develop instrumentation "on paper," using mathematical models, computer analyses, prints, and artist's sketches, it is also desirable to check out at an early design stage the actual operation of displays, controls, and their interactions. Few persons familiar with the design of major weapons systems would consider it feasible to design a simulator of the complete system during the research and development phase.

An effective solution to the problem was recently worked out by General Electric Co. researchers. Human-factors engineers at GE's Light Military Electronics Dept. developed a "display generator" which was used successfully to check out a highly sophisticated bomb/navigation system. They used inexpensive laboratory equipment (major item was a tv camera) to simulate CRT displays. Wood and steel mock-ups, to which magnetized knobs, switches, and dials were attached, added the necessary finishing touches to the simulator.

According to Dr. R. A. Ibison, former GE human - factors expert who worked on the project, there is practically no limit to the variety of simulators that can be inexpensively constructed in the laboratory, and their versatility can be enhanced to almost any degree by incorporating a wide variety of optical, electrical, and electromechanical components. He also noted that use of the unsophisticated simulator at GE not only minimized cost, it saved time. Displays were often set up and evaluated in several days.

The Shiftless Tractor . . .

Chances are it will arrive soon, with hydrostatic drive.

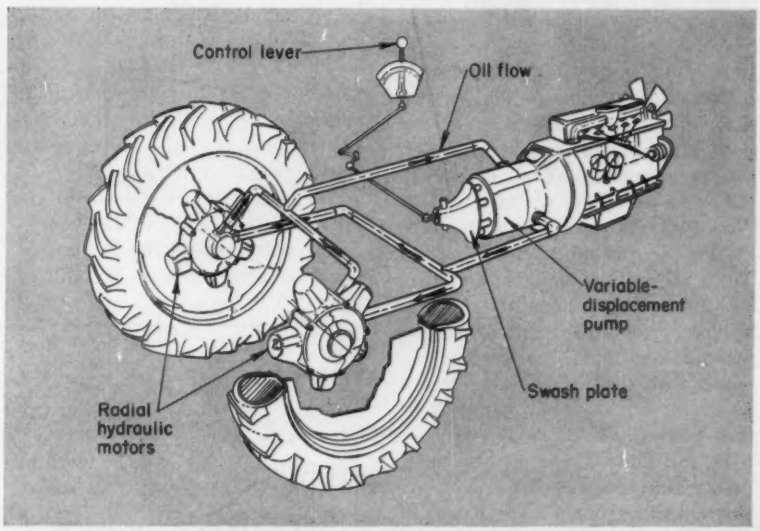
THE SHIFT AWAY FROM GEARS, a characteristic of vehicle design during the past 20 years, has yet to reach the farm. This, despite the fact that the ordinary tractor is an ideal application for an automatic transmission.

Torque converters have been modified and remodified, and so have hydromatics, but neither has proved entirely satisfactory for the slow-moving heavily loaded farm tractor.

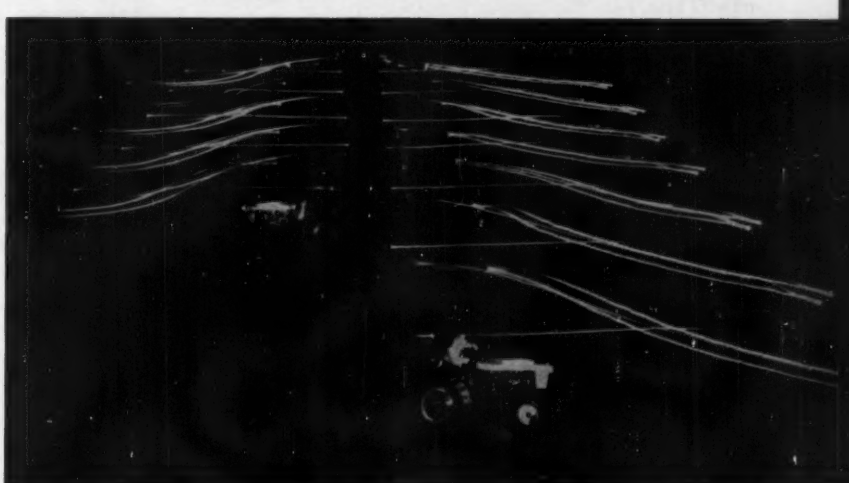
Another perennial transmission favorite among tractor designers is the hydrostatic drive. And with recent advancements in hydraulic-component design, the hydrostatic may well succeed. Designers at International Harvester Co. are now testing a hydrostatic tractor and are noticeably impressed by its performance.

At first glance, the IH tractor seems to be missing a number of essentials. It has no clutch, brake pedals, or gear shift lever. There's no rear axle, either—only a yoke that serves as a structural member. The big, hollow, main frame casting that houses transmission and differential in conventional tractors is also gone, along with the entire complex of gears, shafts, and splines that have always been needed to send power from engine to driving wheels.

Despite the dramatic lack of parts, the tractor runs—and with a notable reduction in driver effort. Once the engine is started, a single lever on a quadrant near the steering wheel starts forward or reverse motion. It controls speed over an infinitely variable range without clutch and without gears to shift. The change from forward to reverse motion requires a simple, corresponding movement of the control lever. In neutral, the lever stops the tractor



Radial hydraulic motors and a variable-displacement pump make up the hydrostatic drive in International Harvester's experimental tractor. Assuming that the transmission resembles previous hydrostatic units, the pump operates at exceptionally high efficiencies and at pressures of about 5000 psi.



Ability to shift quickly is one of the virtues of the hydrostatic drive. Simple one-lever control permitted the test tractor (right) to outperform a conventional tractor in the number of forward-to-reverse shifts accomplished in a given time.

as positively as any band or shoe brake.

Devised for evaluation by IH Engineering Research Group, the hydrostatic drive has three major parts: Two radial piston hydraulic motors—one at each driving wheel—and a variable-displacement pump which furnishes pressure energy to the system. The pump is coupled directly to the tractor engine. Piston action in the motors resembles that in a radial aircraft engine. They act on an eccentric which serves as a crankshaft.

Emphasizing the advantages of the new transmission, IH researchers point to haying operations as an example. A farmer running a baler could set the tractor throttle for maximum horsepower output required to operate the baler and leave it there, controlling forward speed entirely with the transmission.

IH researchers have also designed a load-governing device in the system which automatically reduces forward speed to increase torque as required, as when a plow, for example, hits a hard spot in a field or an ascending slope. The device then returns the system to its previous rate of travel when the added torque is no longer needed.

Study of the new transmission, to date, has revealed dramatic performance characteristics that could hardly fail to attract both farm and industrial tractor users. But the system poses some important problems which will have to be solved before it can compete with gear drives. The need to improve fuel economy is one major problem; high cost of components is another.

Will hydrostatic transmissions replace gear systems in the tractor of the future? IH is counting on current research evaluations to turn up a documented answer.

Resonant Bending Speeds Life Tests on Metal Pipe

LOUISVILLE, KY.—Service life of metal pipe can be checked in minutes by a new resonance-bending technique. The method is reportedly five to six times faster than present ways of determining pipe life and is substantially more economical—power needed, equipment costs, manpower, and maintenance are all decreased.

Lengths of pipe, when forced to vibrate at natural frequencies, shake themselves until they crack, reports Tube Turns Div., Chemetron Corp. Vibrations imposed on test lengths induce sympathetic vibrations at natural resonant frequencies, and when points of suspension match natural nodal points, amplitudes may get quite large.

In the Tube Turns method, node points and resonant frequencies are first calculated for a given length of pipe. Then, with the pipe suspended at its nodes, unbalanced weights, geared to an electric motor, are spun at a calculated speed, setting up forced vibrations in the pipe.

Once the test piece is locked on its natural frequency, amplitude of vibration is increased by stepping up the motor's output. The pipe is under 10 psi pressure, and when a fatigue crack develops pressure quickly falls, automatically shutting off the motor.

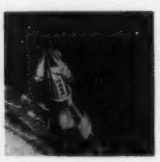
Several thousand cycles a minute can be readily achieved, according to J. D. Mattimore, Tube Turns' vice president for research, and carbon-steel pipe with ½-in. walls can be vibrated to failure in 30 min.

NASA Presents Record Budget—$915 Million

WASHINGTON—The nation's space-exploration program, as outlined before a Senate committee, places heavy emphasis on project Saturn. In outlining the program, Dr. T. Keith Glennan, head of the National Aeronautic and Space Administration, spoke of the U. S.-Soviet space race and admitted that we are behind in lifting ability.

He reminded the committee that the U. S. had entered the race five to six years behind the Soviets, and he spoke of the hodge-podge of missiles being used as launching rockets in U. S. space exploration. But he claimed a strong U. S. lead in miniaturization, and significant scientific results from our fifteen successful satellites and two deep-space probes. By 1964, he stated, our rockets will have as much thrust as the Soviets'.

He spoke of the urgent need for a continuing program of research, and broadly outlined the long term objectives of the present space program's "ten-year plan."



$221,170,000—Project Mercury

As a nonorbital dry run, a rocket is scheduled to throw a Mercury astronaut 120 miles high, for a 13 minute, 200 mile flight, sometime in 1960. In fiscal 1961 $107,750,000 is expected to be spent on research.

$230,000,000—Project Saturn

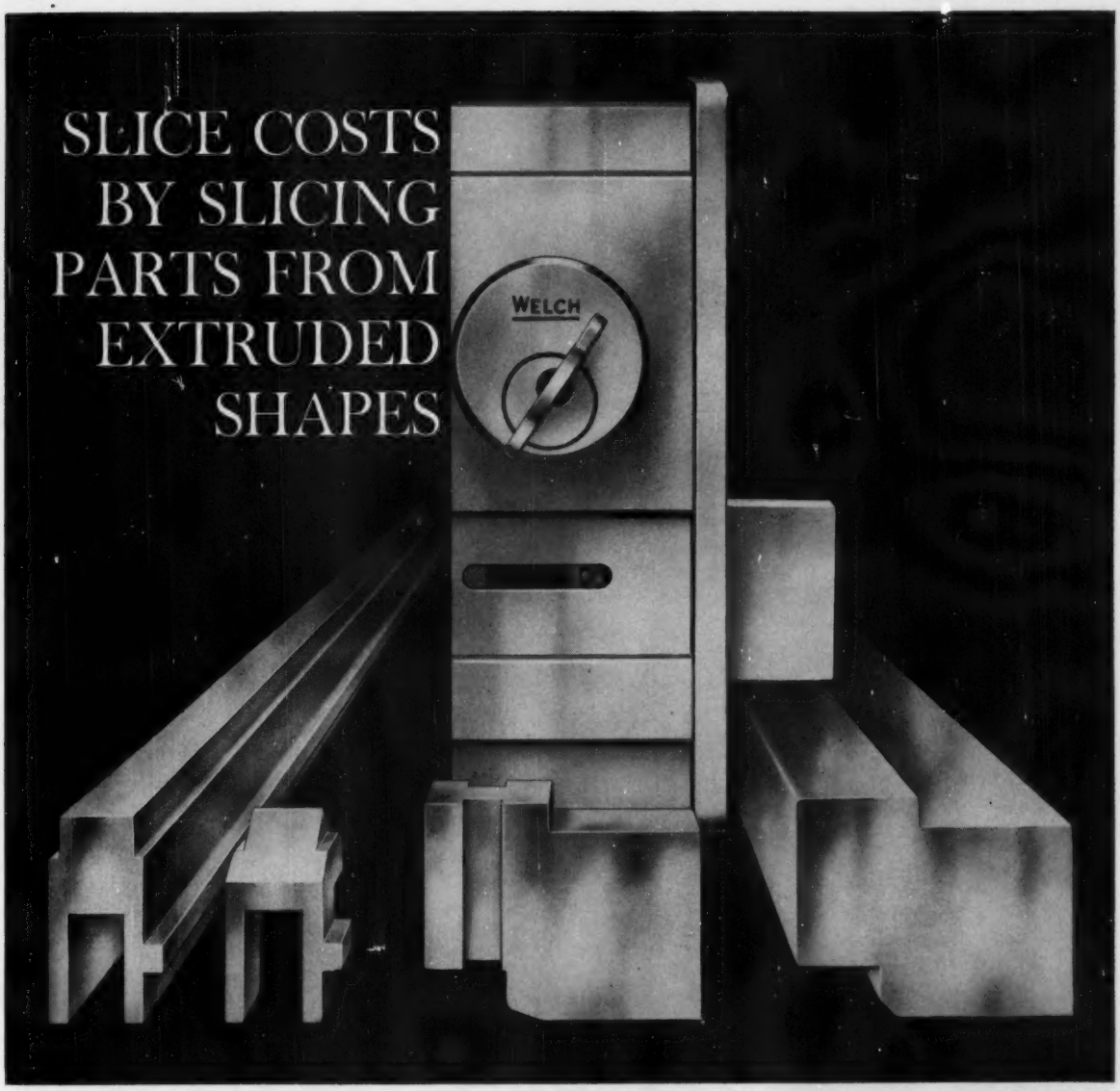
Expected to become operational in 1964, this cluster of eight Jupiter-Thor components will develop 150,000 lb thrust; research costs for fiscal '61 alone are estimated at $134,308,000. NASA claims the Soviets have nothing in the works to beat this.

$41,000,000—The F-1 Engine

From $24 million in fiscal 1960, step-up in this program to develop a 1-million pound thrust engine will produce results "soon."

$423,830,000—Other Projects

Salaries and expenses for the year are estimated at $170,760,000, space probes will account for $94,700,000, and space propulsion development will cost $83,800,000. The balance of the funds is slated for improvement of facilities, such as those at Langley Field, and Wallops Island.



Fabricating parts from long lengths of "premachined" shapes reduces machining, scrap, and finishing

The lock components shown above are typical of some 20 different precision brass parts which Welch, Inc., Waukegan, Ill., makes for its broad line of locks and latches, from Anaconda extruded shapes.

Welch works closely with Anaconda specialists from early design stages. New lock mechanisms are built around parts which can be cut by a metal slitting saw from long lengths of extruded shapes with minimum subsequent machining and scrap. The use of bar stock is never considered when there is the slightest possibility of designing savings into a part by means of a brass extrusion.

Superior quality, too. Parts made from extruded shapes are characterized by their strong, homogeneous, wrought-metal structure. And the smooth, extruded surfaces reduce many finishing operations.

More and more manufacturers are cutting fabricating costs *and* maintaining quality by using these preformed or, in effect, "premachined" shapes. For imaginative and practical help in adapting extruded shapes to the economical production of intricate parts, call your Anaconda representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6044

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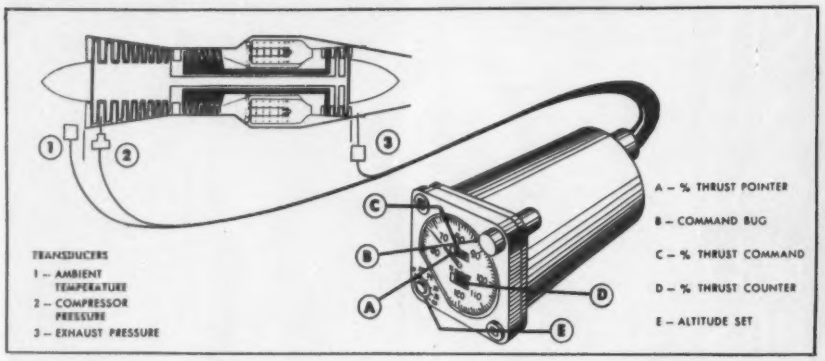
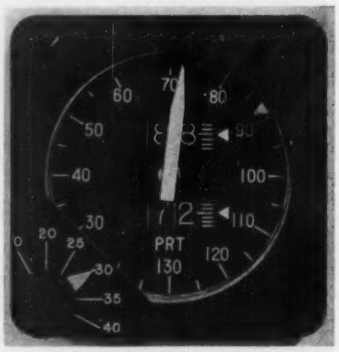
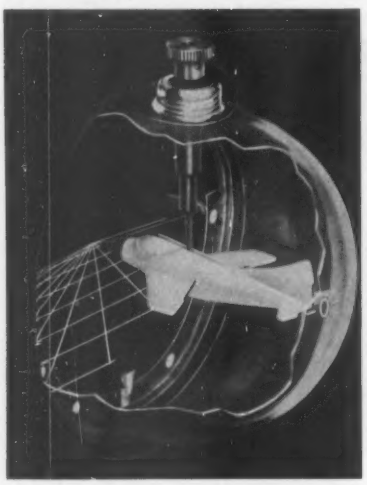
Meter Indicates Jet Engine Thrust


TRANSDUCERS
1 – AMBIENT TEMPERATURE
2 – COMPRESSOR PRESSURE
3 – EXHAUST PRESSURE
A – % THRUST POINTER
B – COMMAND BUG
C – % THRUST COMMAND
D – % THRUST COUNTER
E – ALTITUDE SET



Jet pilots no longer have to choose between approximate answers and lengthy calculations to obtain engine thrust. A new indicator, developed by Astromics Div., Mitchell Camera Corp., connects to three transducers and an altimeter, measures engine pressure ratio (exhaust pressure/compressor pressure), inlet air temperature, and ambient altitude, then integrates the factors to come up with true per cent rated thrust. Although other instruments (several are required) can supply the necessary data, pilots don't always have time to make calculations, so they often rely on pressure ratio—a poor approximation—as a measure of thrust. The new instrument will result in appreciable fuel savings, reduced engine maintenance, and—most important of all—sharply improved flight safety.



Model Plane Cues 3-D Attitude

A new flight instrument which shows the plane in three dimensions simplifies attitude control for light planes. The device, introduced by Coffing Industries, Covington, Ind., consists of a model airplane suspended within a transparent case set in the instrument panel. Ahead of the model is a converging section-line grid pattern depicting horizon and ground. This remains parallel to the ground at all times, so that the degree and direction of roll and bank is shown continuously. Pitch is read by direct reference of the nose-tail attitude of the model as it pivots above or below the horizon line. The horizon-earth grid pattern and trailing edges of wings and elevators of the miniature plane are marked with luminescent paint.

Pilot Flies "Hands Off" To Set 2500-Mile Record

Pre-programmed Flight Plan Stored in Airborne Computer

TYNDALL, FLA.—A nonstop flight across the continent from California to Florida has been accomplished by a computer-controlled F-106 Delta Dart interceptor.

The 2500-mile flight was the longest ever made by an interceptor aircraft without refueling. No attempt was made to set a speed mark, although the Convair-built F-106 holds the world's speed record of 1525 mph.

Maj. Frank Forsyth, chief acceptance pilot for the F-106, took the Delta interceptor off the Palmdale, Calif. runway at 8:48 a.m., PST. Seconds later the F-106 picked up an electronic signal from the ground and Forsyth took his hands from the controls. The F-106 then "flew itself" to Jacksonville, Fla., where Forsyth took control, turned and flew back to Tyndall AFB. Flying time for the aircraft was 3 hours and 17 minutes to Jacksonville, for the pilot, about 5 minutes total stick time.

Key to the fully automatic flight was the aircraft's MA-1 navigation and fire-control system, built by the Hughes Aircraft Co. Before the F-106 took off, engineers pre-programmed its entire flight profile into the MA-1 system's "Digitair" airborne digital computer. It included such information as route, altitude, and fuel available.

With this data and continuous range and bearing information flashed to the speeding aircraft by TACAN (tactical air navigation) stations across the country, the Hughes system compared the jet's position to the prescribed route and supplied signals to the airborne flight-control system to correct heading and altitude.

"It was like riding in the back seat of a limousine with a tv set and someone else doing the driving," said Forsyth. "All I did was flick a couple of dials to set up new maps on the horizontal situation indicator screen as we passed from one TACAN station area to another . . . like switching from one channel to another."

Signals from each new TACAN station automatically projected new 400-mile-diameter map areas on Forsyth's tactical situation display screen. These signals tuned the interceptor's radio receiver to the proper wave length and informed the computer which map was being displayed. Forsyth's precise position in relation to the terrain below was indicated on the screen by a constantly moving symbol of his plane. The F-106 carried external fuel tanks during part of the trip.

WELDED STEEL PRESSURE TUBING

UNIFORMLY ROUND, DEPENDABLY SOUND—readily shaped and assembled

For every designer, the many thousands of miles of welded steel tubing in boilers, heat exchangers, evaporators and condensers throughout America prove these facts: welded steel tubing has dependable strength (*what pressures do you need?*) . . . it is easily formed (*are special shapes your problem?*) . . . it is accurately concentric (*will you use more drilled holes than a steam drum?*) . . . and has no hidden interior imperfections (*the rolled steel from which welded tubing is made is sound and smooth*).

These are reassuring facts to count on, whatever your product where tubing is used. They mean easier fabrication at lower cost, together with complete dependability in performance on the job.

Great design freedom is provided by the wide range of carbon and stainless grades at your command in welded steel tubing. Write for data-filled Bulletin 8591—and for immediate information on your current requirements, call a quality welded tube producer.

LC-603

FORMED STEEL TUBE INSTITUTE, INC.

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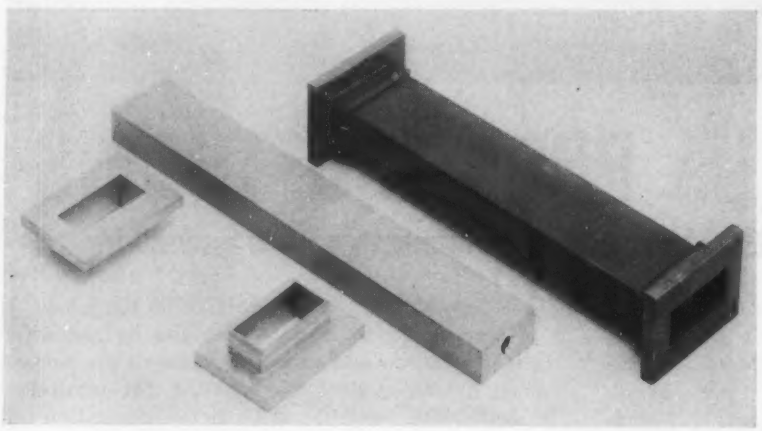
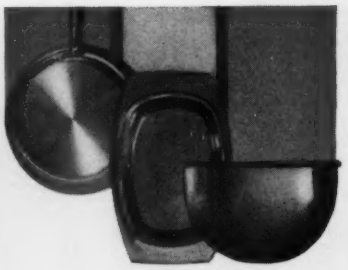
Electronic Tube Brightens Things Up

Objects so dim as to be invisible to the naked eye are being seen with a new electronic amplifier. Dr. J. W. Coltman, manager nuclear physics dept., Westinghouse Research Labs, who developed the tube, said that amplification amounts to "many thousands of times." Photons from the dim object are focused by lenses onto a light-sensitive screen. On striking it they eject electrons, which are accelerated into another screen. Here, more electrons are ejected, and in turn, accelerated. By use of five such screens, electron flux is multiplied by three thousand, then aimed at a fluorescent screen at the output end of the tube, to release about twenty thousand photons.



Electroplating Joins Parts

Where soldering or brazing is unsuitable because of heat deformation, a method developed by Allied Record Mfg. Co., Los Angeles, provides the solution. Two metal parts to be joined structurally are placed in position, and an electro-deposition is made over the entire joint area. Thickness of the deposit can be accurately controlled to insure adequate strength, and there is no heat generated. Waveguide illustrated was originally fabricated from 5-ft lengths of Invar; end flanges were silver soldered in place. Heat required to attach the flanges warped the tubing, oxidized its surface, and destroyed its thermal properties. Redesigned assembly was made by electro-depositing body over the mandrel, pressing flanges in place, and securing them by further electro-deposition.



call WESTERN UNION operator 25

Your J&L stainless steel distributor can serve you better *because J&L serves him better*, backing him with the full facilities of J&L's Stainless and Strip Division.

Your J&L distributor can reduce your costs by providing a complete range of pre-production services, and doing it economically! He can save you the capital investment required to maintain long term inventories; he can help you eliminate the costs of overhead connected with stocking, accounting, and the inevitable losses incurred through waste and obsolescence due to specification changes.

Technical assistance in solving production problems is also available from your J&L distributor . . . when those problems are connected with an application using stainless steel, J&L's own staff of technical specialists will promptly answer your distributor's call for additional help.

Even when advanced research is required you can call on your J&L distributor in confidence. He will be happy to discuss your problem because he knows he is backed by one of the world's most respected teams of metallurgists—J&L's own staff in laboratories at Detroit and the famous Graham Research Laboratories at Pittsburgh.

Your J&L distributor is as near as your telephone. Call Western Union Operator 25 for the name of your J&L distributor of Consistent Quality stainless steel.

J&L — a leading producer of stainless steel and precision cold rolled strip steels

J&L STAINLESS

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Circle 418 on Page 19

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Call Western Union by number – ask for Operator 25
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Outstandingly different!

The Mayline

DESK-O-MATIC

The *New* desk height drafting table

The Desk-O-Matic is the only fully adjustable, automatic, desk high drafting table that permits the operator to change angle of top or height of top, instantly, without moving from his position at the front of the table. *No other drafting table provides this convenience.*

Also, this table has counterbalance adjustments to insure consistent smooth operation of changes in both top height and tilt, and to compensate for weight added to top by drafting machine, light, and other equipment. The Desk-O-Matic drafting top holds steady regardless of height or angle position.

Mayline invites you to see this new table when you attend either the A.S.T.M.E. show in Detroit, or the Design Engineering show in New York. Your inquiry to the factory will bring literature promptly.

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DESIGN ENGINEERING SHOW
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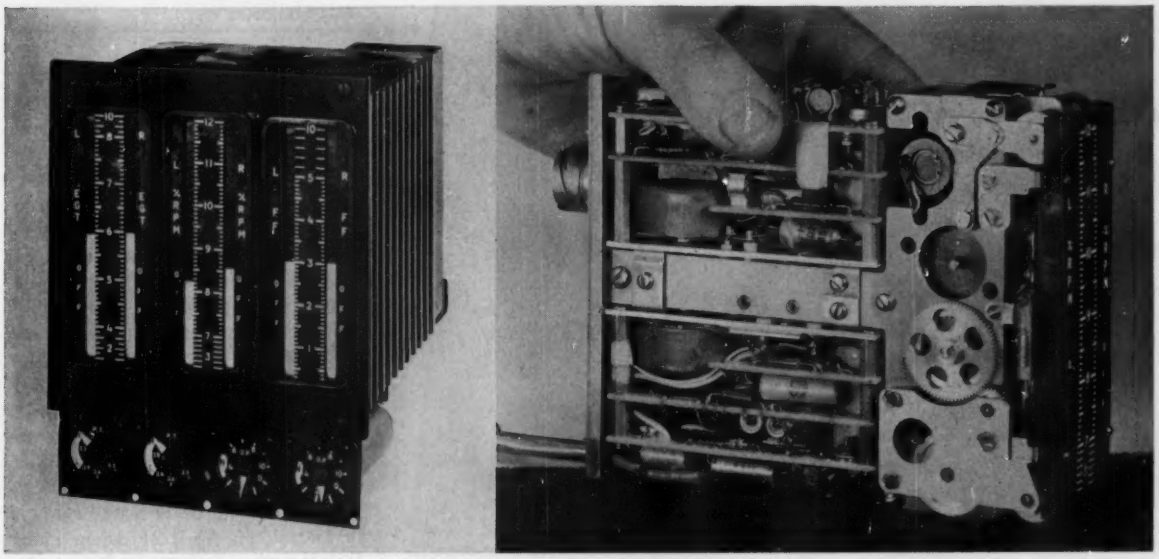
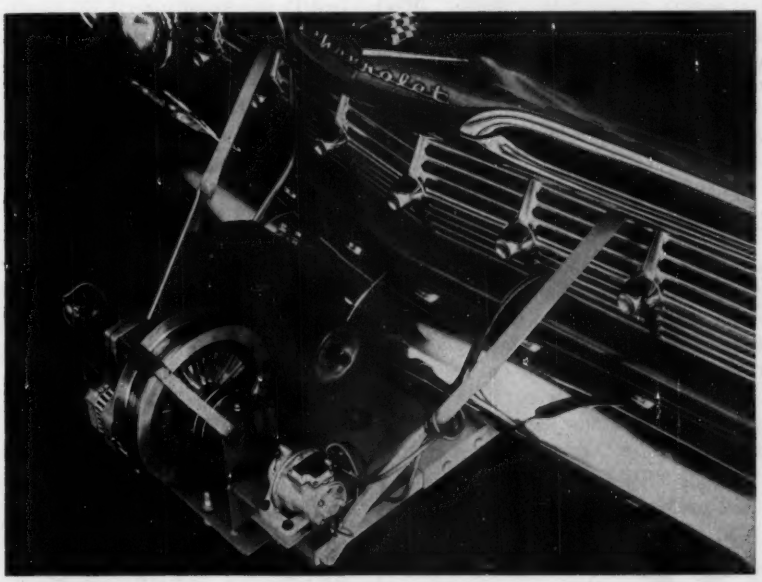


Bar Display Checks Jet Pulse

A quick eye movement, sweeping about six inches on the instrument panel of Navy's A2F-1, is expected to save pilots' lives. Human factors engineering techniques were used in designing the plane's instruments to ensure that the pilot would interpret information displayed in minimum time. The A2F-1 will approach enemy targets at ground level and near-sonic speeds to avoid radar detection. In the new display, designed by General Electric Company, Schenectady, N. Y., in close co-operation with Grumman Aircraft Corp., conventional round dials are replaced by a compact group of vertical column indicators. The two engines' functions are exhibited side by side, and scale readings are indicated by moving white bands. With this arrangement, pilots can recognize engine malfunction merely by noting that one of the white bands is not lined up. Internal design of the scales is an endless belt moving over a sprocket-driven tape. A transistorized servo-driven measuring circuit affords great accuracy.



Traffic Flow Prediction from Two-Car Tests

We're all good drivers—instinctively. At least the latest tests aimed at speeding up city traffic show this fairly conclusively. A wire between two cars measures separation distance and relative speed, from which a recording drum plots relative velocity and acceleration. The information shows that drivers are affected not only by the next car, but by those as far as five or even ten ahead, and by the car behind. This fact, says General Motors Research Div., of Warren, Mich., can be used to predict maximum traffic flow in general highway situations.

Fluid Power Society: New Technical Organization

MILWAUKEE—A brand new technical organization, the Fluid Power Society, has been formed to bring together "all persons interested or engaged in any activity which may further the development and use of fluid power."

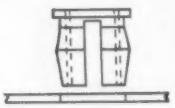
Formation of the new society is the result of collaboration between the National Fluid Power Association and the Industrial Hydraulics Training Association. NFPA, formed in 1953, is the trade association for the industry, and only companies (not individuals) are eligible for membership. The Industrial Hydraulics Training Association was organized in 1957 to bring together a group of instructors of industrial hydraulics in the Detroit area for educational purposes.

Qualifications for membership in the new Fluid Power Society are not restrictive. This, it is hoped, will bring together persons interested in all phases of the general subject—research, development, application,

"We recommend Banc-Lok tapped holes

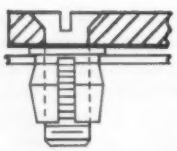
for attaching surface hardware to all of our hollow metal doors and frames. Easy to install, they provide more than sufficient holding power for the installation and function of heavy-duty hardware",

says E. A. Mauthe, Chief Engineer of the Building Products Division of American Welding and Manufacturing Company.



Laboratory tests conducted by Amweld convinced them of Banc-Lok's superior holding power. A test sample mounted with Banc-Lok tapped holes was subjected to a tension of 800 pounds, at which point the steel sheet itself began to bulge, but the Banc-Loks held firm. Such strength makes it possible for Amweld to eliminate costly reinforcement on 16 and 14 gauge frames. Amweld finds Banc-Loks "quick, simple, inexpensive and trouble-free".

Wherever screw threads with locking action are required Banc-Lok solves the fastener problem. Of one piece construction with no external threads, Banc-Loks are merely pressed into a prepared hole in a single operation, without special tools or extra locking devices. Find out how Banc-Loks can improve your product, save money—WRITE FOR OUR NEW CATALOG.



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design, installation, operation, maintenance, and education—and those serving all fields of utilization—industrial, aviation, marine, mobile, material handling, agricultural implements, etc.

Membership is on an individual basis, but the Society will carry on its principal activities through local chapters which will be given much latitude in determining local fields of interest. It is expected that some chapters will contain several sections; and that in some of the larger cities there will be more than one chapter, each specializing in a different major interest.

First meeting of FPS will be held in Detroit on April 21, when members of the Industrial Hydraulics Training Association will be chartered as Chapter No. 1. Persons not affiliated with IHTA are invited to attend the meeting. Chapter No. 2 is being formed in Milwaukee, and other applications are pending. It is expected that by the end of 1961 there will be local units in all of the principal cities in the U. S. and Canada.

Further information about FPS can be obtained from Barrett Rogers, executive Vice President, National Fluid Power Association, 5595 North Hollywood Avenue, Milwaukee 17, Wisconsin.

Meetings and Shows

April 21-28—

American Society of Tool and Manufacturing Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 25-27—

Metal Powder Industries Federation. Annual Technical Meeting and Powder Metallurgy Trade Show to be held at the Drake Hotel, Chicago. Additional information can be obtained from MPIF, 60 E. 42nd St., New York 17, N. Y.

April 25-29—

American Welding Society. 41st Annual Convention and Welding

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Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS, 33 W. 39th St., New York 18, N. Y.

April 27-28—

National Conference on Space-Age Materials to be held at the Sheraton-Gibson Hotel, Cincinnati. Sponsor is the Cincinnati Chapter of the American Society for Metals. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

May 3-5—

National Association of Relay Manufacturers. Eighth Annual Conference on Electromagnetic Relays to be held at Oklahoma State University, Stillwater, Okla. Additional information is available from Prof. Charles F. Cameron, P. O. Box 6, Stillwater, Okla.

May 3-5—

Western Joint Computer Conference to be held at the Jack Tar Hotel, San Francisco. Sponsors are Institute of Radio Engineers, American Institue of Electrical Engineers, and Association for Computing Machinery. Further information can be obtained from William C. Estler, 965 Lincoln Ave., Palo Alto, Calif.

May 7-13—

Society of the Plastics Industry Inc. National Conference and Annual Meeting to be held on the *Queen of Bermuda.* Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

May 9-11—

National Fluid Power Association. Spring Meeting to be held at the Grand Hotel, Point Clear, Ala. Additional information is available from Barrett Rogers, executive secretary of NFPA, 5595 N. Hollywood Ave., Milwaukee 17, Wis.

May 9-12—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Civic Auditorium and Brooks Hall, San

Hub assembly with integral preloaded duplex ball bearing, used in electronic missile system developed by Westinghouse Air Arm.

"IN-BORN" BEARING IN HUB ASSEMBLY

Gives Better Accuracy, Weight and Cost

Important advantages can often be gained by "designing in" bearings as a part of the unit in which they operate. A case in point is this hub assembly, produced and bearing-engineered by ITI.

Here, the two outer raceways and one inner raceway are formed in the hub and shaft; and the second inner ring – made separate to permit assembly – is close to a zero-tolerance fit. Compared to the usual design (using separate bearings), this construction gives (1) higher and more uniform accuracy, through elimination of 6 radial tolerances; (2) less weight and greater compactness, by eliminating 3 rings; and (3) lower total cost.

Other features include low running torque, labyrinth seals, high vibration resistance, and a dished hub held within .001" of the mathematically-specified contour.

In comparable ways, you too can benefit through our ability to design and produce bearings having unusual compactness or configuration, heat resistance, corrosion resistance, ultra precision, or other special properties. Let's talk it over.

FREE BULLETIN AFB-2 tells about the factors involved in special bearing applications, describes our work in this field, and shows a wide variety of special bearings. Write for it!

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BEARING DIVISION PLANT: COMPTON, CALIF.

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Francisco. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 9-13—

American Society for Metals. Second Southwestern Metal Exposition and Congress to be held at the Sheraton-Dallas Hotel and State Fair Park, Dallas. Additional information is available from ASM, Metals Park, Novelty, Ohio.

May 9-13—

American Foundrymen's Society. Castings Congress and Exposition to be held in Convention Hall, Philadelphia. Additional information is available from AFS, Golf and Wolf Roads, Des Plaines, Ill.

May 9-13—

Society of Photographic Scientists and Engineers. Annual Conference to be held at the Miramar Hotel, Los Angeles. Additional information can be obtained from the society, Box 1609 Main Post Office, Washington, D. C.

May 11-14—

American Helicopter Society. 16th Annual National Forum to be held at the Sheraton Park Hotel, Washington, D. C. Further information can be obtained from AHS executive secretary Harry M. Lounsbury, 2 E. 64th St., New York 21, N. Y.

May 11-14—

Fluid Controls Institute Inc. Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from E. R. Rath, P. O. Box 667, Pompano Beach, Fla.

May 17-19—

American Society of Mechanical Engineers. Production Engineering Conference to be held at the Hotel Schroeder, Milwaukee. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

May 22-26—

American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

May 23-25—

Ninth National Telemetering Conference to be held at the Miramar Hotel, Santa Monica, Calif. Conference is sponsored by Instrument Society of America, American Institute of Electrical Engineers, American Rocket Society, and Institute of Aeronautical Sciences. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

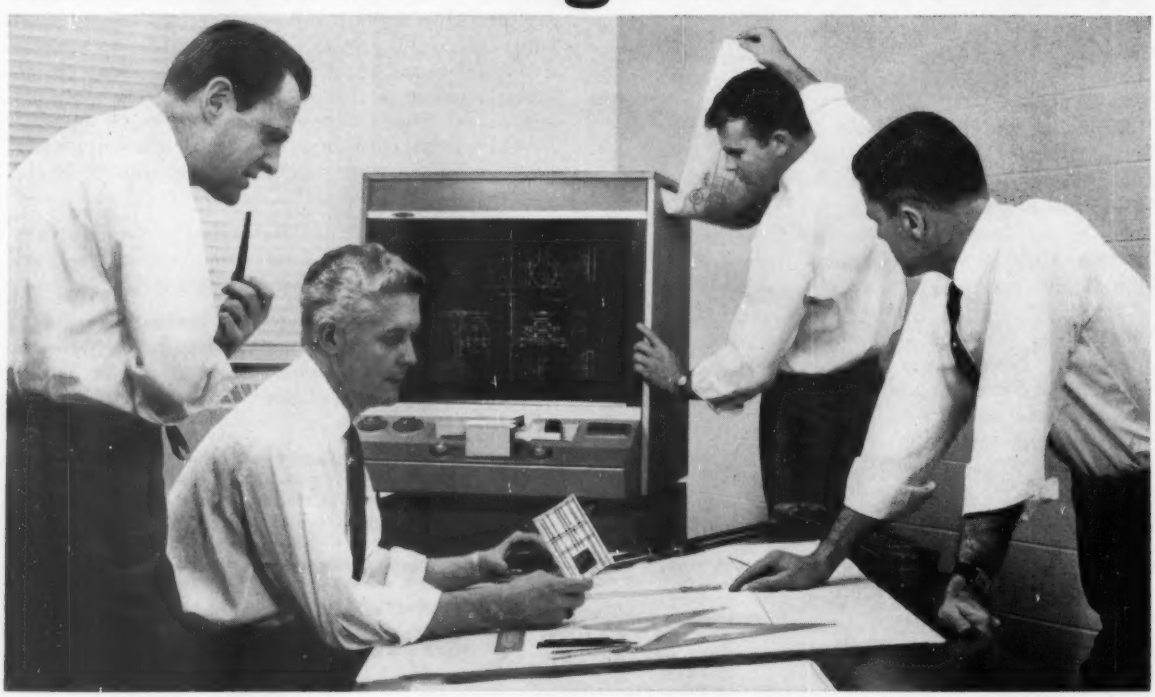
May 23-26—

Design Engineering Show and Conference to be held at the Coliseum, New York. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 23-27—

American Textile Machinery Association. International Exhibition

It's time for engineers to take



to be held at Convention Hall, Atlantic City, N. J. Further information is available from ATMA executive secretary, Mildred B. Andrews, P. O. Box 596, Vienna, Va.

May 26-28—

Society of Naval Architects and Marine Engineers. Spring Meeting to be held at the Statler Hilton Hotel, Washington, D. C. Further information is available from SNAME, 74 Trinity Place, New York 6, N. Y.

June 5-9—

American Society of Mechanical Engineers. Summer Annual Meeting and Aviation Conference to be held at the Statler Hilton Hotel, Dallas. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

June 5-10—

Society of Automotive Engineers Inc. Summer Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

June 6-7—

Malleable Founders Society. Annual Meeting to be held at the Elbow Beach Surf Club, Hamilton, Bermuda. Further information can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

MACHINE DESIGN

"So I told the missile division I couldn't spare an engineer and they'd have to work out their replacement problems themselves."

June 6-8—

American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. Further information is available from AGMA headquarters, 1 Thomas Circle, N. W., Washington 5, D. C.

June 8-11—

National Society of Professional Engineers. Annual Meeting to be held at the Statler Hotel, Boston. Additional information can be obtained from NSPE headquarters, 2029 K St., N.W., Washington 6, D. C.

June 13-15—

American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Sixty-seventh Annual Meeting to be held at the Vancouver Hotel, Vancouver, B. C. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

a new look at microfilm

■ Today microfilm is an active partner to production machines in modern plants—and is just as busy. Today engineers, methods and procedure specialists, reproduction supervisors, and industrial management use microfilm to solve paperwork problems and speed production. ■ Microfilm makes wonderful things happen. It standardizes records and drawings. It speeds reference. It simplifies filing. It shrinks file space—because with microfilm aperture cards you file 100% of your material in 4% of the space. It improves security. It raises efficiency, lowers overhead. ■ The only thing you need to make microfilm active—usable daily—is a THERMO-FAX "Filmac 200" Reader-Printer. Developed by 3M research, "Filmac 200" Reader-Printers combine the functions of a reader and a printer in a single low cost unit. You read the film clearly on the big screen. When you want a print, just touch a button and in seconds you'll have a copy—enlarged up to 18 x 24 inches. ■ THERMO-FAX "Filmac 200" Reader-Printers in a reproduction department and at multiple point-of-use installations make microfilm practical for any industry. There are many "Filmac" Reader-Printers actively at work today in a variety of operations—saving time, money, and improving efficiency. We invite you to take a new look at microfilm now. Mail the coupon for a free copy of "Let's Take a Positive Look at Microfilm"... a twelve page booklet about microfilm at work.

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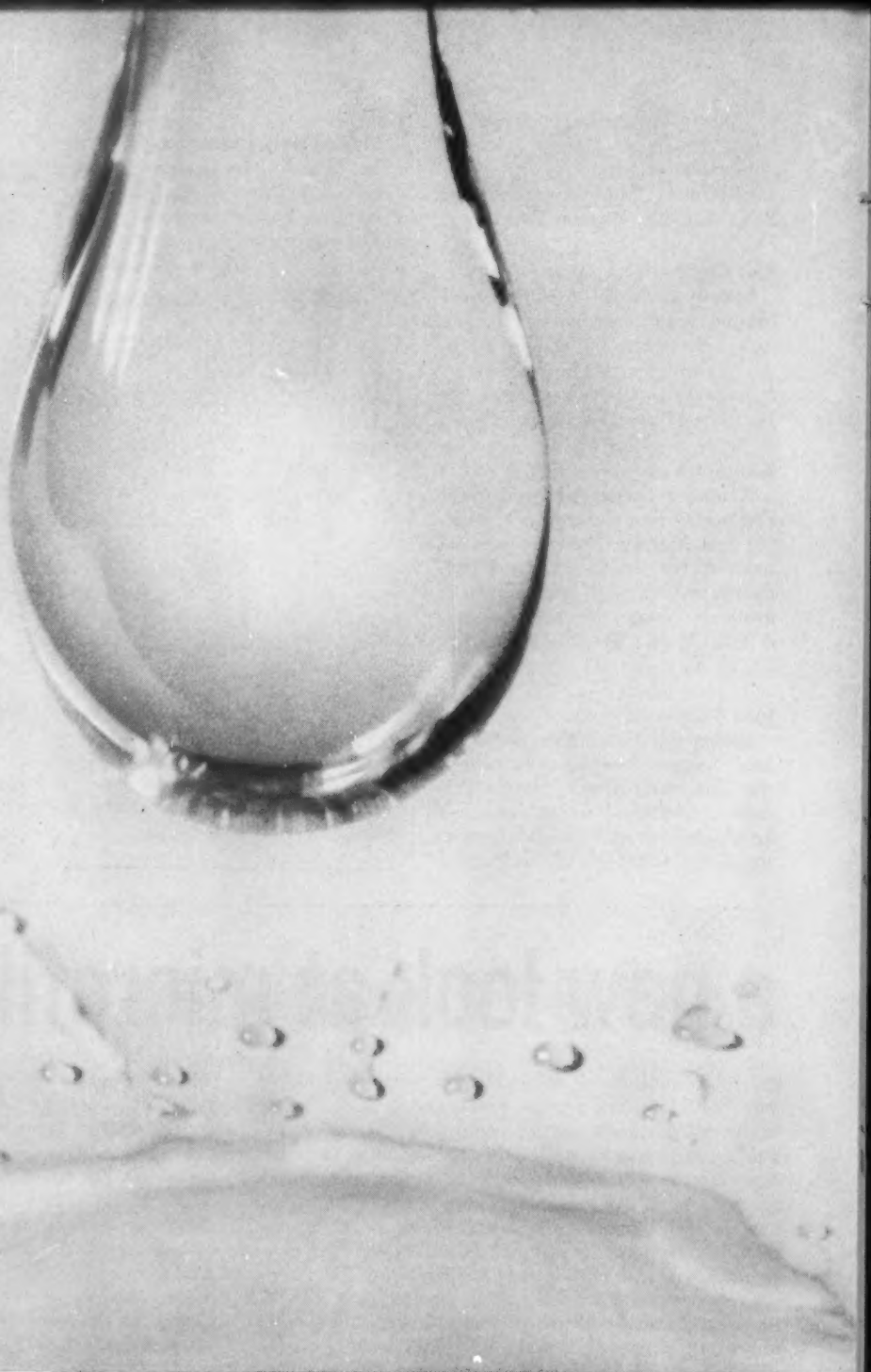

comes in oceans, rivers, lakes, wells,
drops, buckets, pitchers and glasses.
it quenches thirsts, cooks food, puts
out fires, makes coffee and
brushes teeth. it spins mills,
runs electro-plants, cools motors
and power factories.
it spawns fish, sprinkles lawns,
floats boats, washes children
and grows flowers.

it sustains and nurtures.
it bends if you give it purpose.
it reshapes itself if you give it reason.
it is needed, wanted, feared,
praised and prayed for.

it is at the heart of all life.
it is in the arteries of all industry.
it is as close to us as skin
but as taken for granted as sky.

the end of water seems unbelievable.
if it is not on the horizon, it is just over it.
if it is not within sight,
it is just 'round the bend.
if it is not in the glass,
it is just in the spigot.

. . . this is the grand mirage . . .
the self-delusion that prevails
though the wells run low
and the streams go dry
and the water slips away.

we know water.
we know its ways.
we've learned its habits.
we've pulled it out of swamplands,
pushed it over mountains,
pumped it into deserts,
tunneled it through granite,
and rescued it from pollution.

above all else,
we know the need for it.
that is why,
for 130 years,
we've developed new uses for,
powered new factories with,
diverted the courses of
and jealously stood guard over
water.

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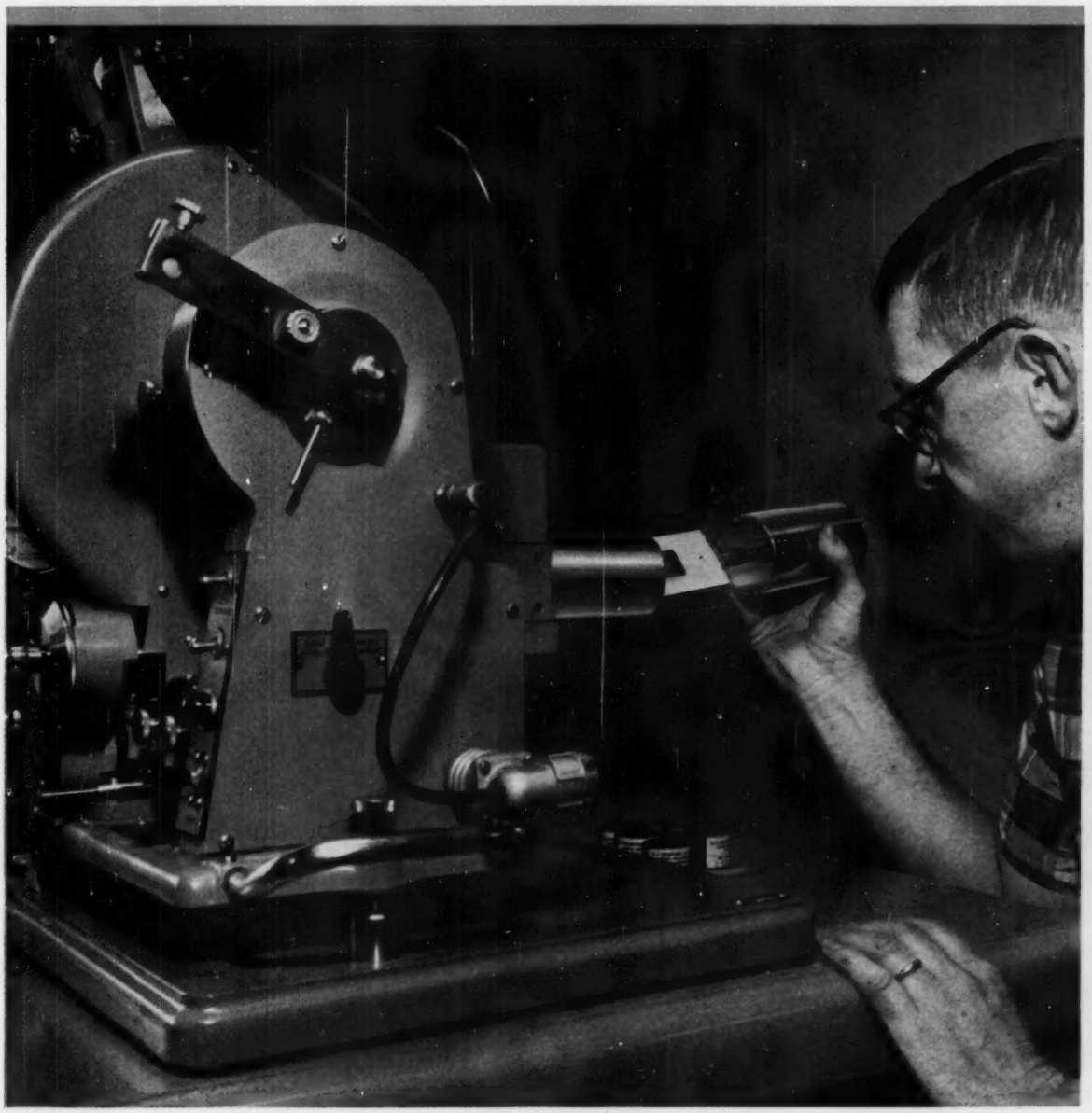
No other manufacturer makes pumps for such a variety of hydraulic applications as Fairbanks, Morse. If it's liquid . . . if it flows . . . we make the pumps that move it . . . at low cost per gallon . . . in sizes from 200 gph to 800,000 gpm, and to 3000 psi . . . for every industrial need.

Our pumps . . . our generators and controls . . . our new rotary compressors . . . our drive toward better ways to de-salt ocean water . . . the potential of our advance Research & Development Center in Beloit . . . our lead position in the field of Hydrodynamics . . . all of these equip us to serve you.

Send for our brochure—"Hydrodynamics." Please write to Mr. Robert W. Kerr, President, Fairbanks, Morse & Company, 600 South Michigan Ave., Chicago 5, Illinois. ***Circle 423 on Page 19***

Laboratory facilities at Standard have kept well in step with the revolutionary advances which have been made in the field of metallurgy during the past decade. Plant facilities, too, are geared to produce even the most exotic of special alloys which today's industry demands.

And Standard's famed personalized service means that your most difficult problems can be resolved by our metallurgists and engineers and assures a finished product which meets your most exacting requirements, delivered in record time. Write today for the illustrated booklet, "Quality Control at Standard."



Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

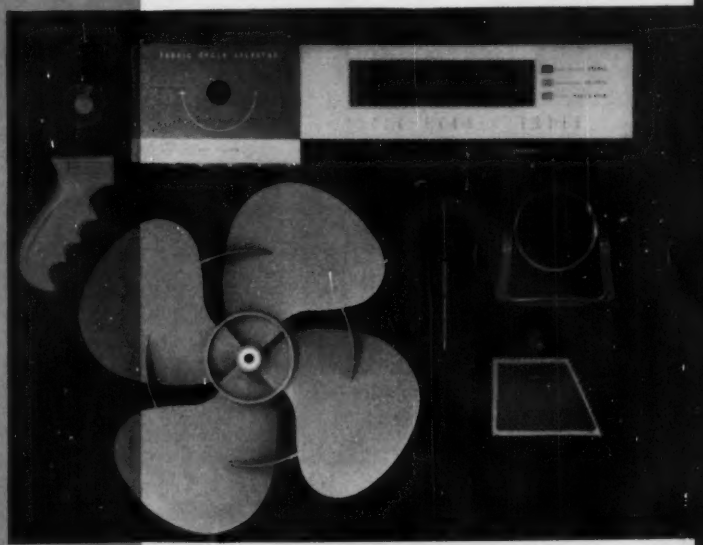
Circle 424 on Page 19

How the custom molder can help bring your product idea to life

The custom molder is well-known as a mass producer of molded plastics parts and products. But he is much more. Most helpful to the designer, the custom molder knows the design limits of the different plastics. He can recommend the best formulation for the job. He can also engineer the design to capitalize on the inherent advantages of plastics materials and the efficiencies of plastics manufacturing. His toolmakers build the master molds to the closest tolerances. His productive facilities can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

Monsanto keeps the custom molder supplied with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet a wide range of design requirements.

Which molding compounds to consider? Use the Plastics Properties Calculator, an easy-to-read slide rule that provides comparative property data on the many different plastics molding materials. For your free calculator, write to Monsanto Chemical Company, Plastics Division, Room 732, Springfield 2, Mass.

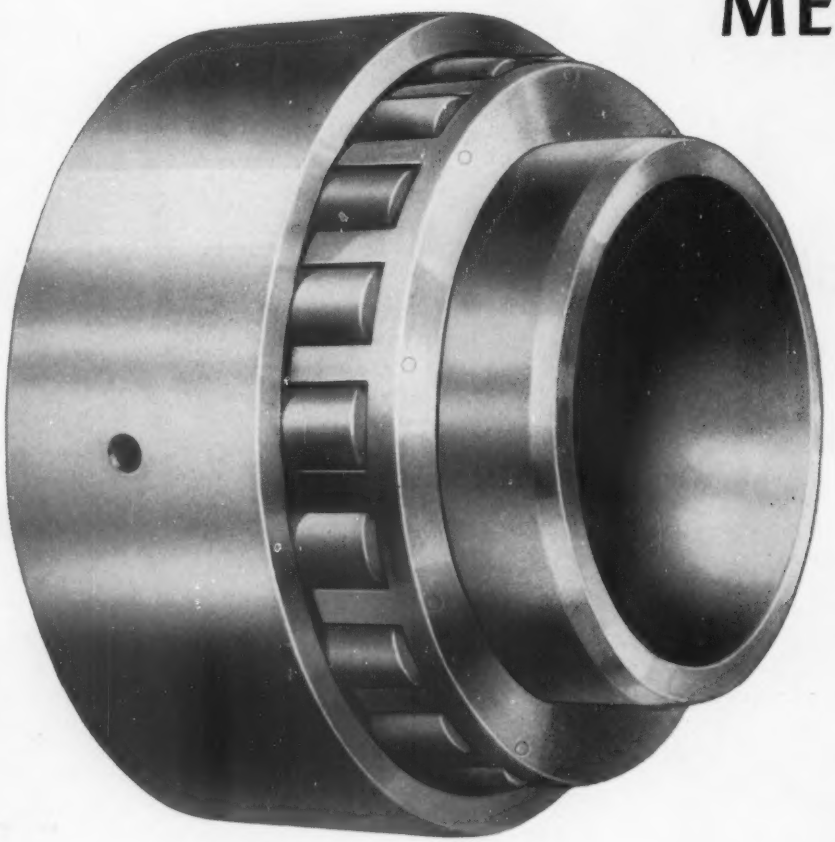


MONSANTO ACTIVATOR IN **PLASTICS**

Monsanto

Circle 425 on Page 19

Rugged IS THE WORD... *for* RADIAL ROLLER BEARINGS *by* MESSINGER



TYPICAL APPLICATIONS

Straightener Rolls; Back-up Rolls; Press Rolls; Work Rolls; Drive Shafts of all kinds; Beaters; Embossers; Rudder Shafts; Heavy-duty Cranes.

The list at right is merely indicative of the wide range of applications for these *quality* bearings... developed by Messinger to assure long service with enduring accuracy. Made from Messinger special analysis bearing steel, through-hardened in the Messinger heat treating plant. The rugged bronze cages contribute importantly to the long life and efficiency of these reliable bearings, particularly at high speeds.

Messinger Radial Roller Bearings are available in the following standard types and combinations: Plain; Self-Aligning With Adapter; Self-Aligning Without Adapter; Combination Radial and Thrust Bearing; Combination Radial and "X" Bearing. All are designed to carry extremely heavy loads with less space and weight. Standard sizes range from 4" I.D. to 60" I.D. Special types and sizes can readily be designed.

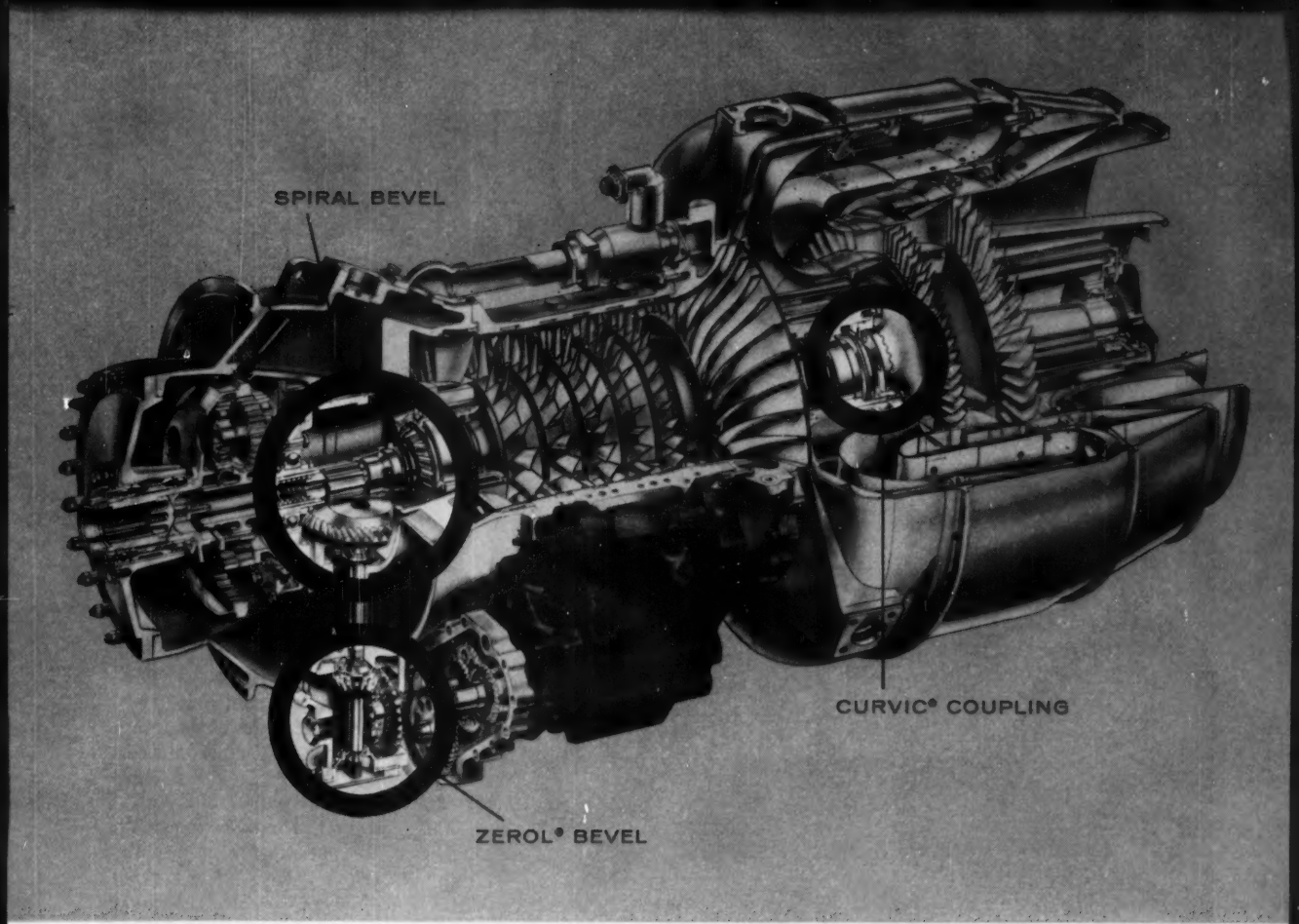
Radial Roller Bearings are just one of many types of bearings developed by Messinger to provide new measures of precision, compactness and long life. Engineering consultation invited, without obligation.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"



How to get *engineering assistance* on gears and couplings like these

Gleason engineers are always ready to help you work out any problems involving bevel gears and couplings.

Such assistance came to the makers of this turbine in four different areas:

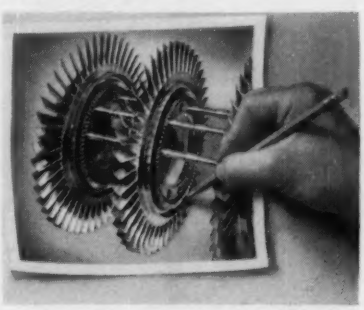
First, they naturally wanted components which met the designated theoretical requirements of the turbine. Our engineers helped determine the types and sizes of the gears and Curvic® coupling as well as such details as axial thrust and radial load.

Second, they wanted compactness. The angular drives made possible by the spiral bevel and Zerol® bevel systems helped materially to fit the drive into the limitations set by the turbine's over-all dimensions.

Third, they wanted low costs. The machines and methods developed by Gleason engineers assure the lowest possible costs for both gears and couplings whether made in small or large quantities. The Curvic coupling design inherently cuts coupling costs; see picture at right.

Fourth, the makers wanted extreme reliability. The success of the gears and couplings in this respect is witnessed by the fact that this turbine is used by six major aircraft companies and has recorded more hours of flying time than any other turbine in its power class.

If you would like to discuss your bevel gear or coupling application with a Gleason representative, please contact us.



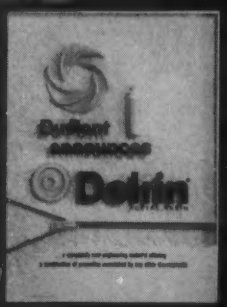
With Curvic couplings complex machine parts can be made in several small units, reducing machining time, simplifying final assembly, and cutting over-all manufacturing costs.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Circle 427 on Page 19

THIS IS DU PONT DELRIN®



a new engineering material offering the user distinct performance and cost advantages in many applications once reserved for metals

The three new products on the opposite page typify the performance and cost advantages that "Delrin" acetal resin offers over die-cast zinc and aluminum, cast and machined brass, stainless steel and cast iron.

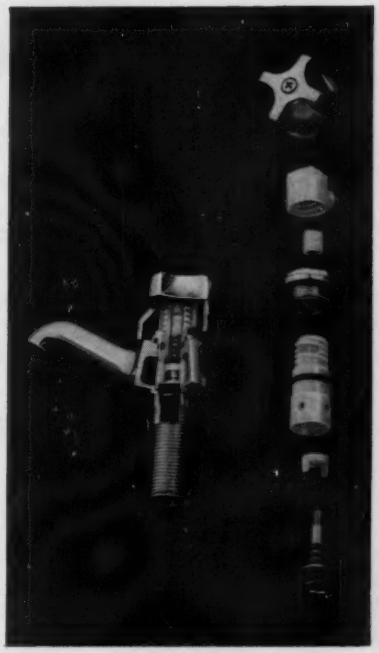
Ronson, for example, has reduced a part's weight by 80%... Kel-Win cut production costs by 80% ... Lionel saves on assembly with a one-piece coupler design.

This ability of "Delrin" to perform in many areas once reserved for metals stems from its unique combination of properties. "Delrin" has the stiffness to remain rigid in large sections, the tensile and flexural strength to withstand high-stress loadings, the dimensional stability to hold close tolerances and the abrasion resistance to operate usually without lubrication. "Delrin" retains these properties even under exposure to wide variations in temperature, humidity, solvents and stress.

"Delrin" also offers the user the economies of production via injection molding and extrusion—processes that can usually reduce costs by eliminating all finishing operations. Part-to-part uniformity minimizes rejects. To simplify assembly, parts may be joined by mechanical fasteners, spin welding, snap and interference fits or often designed as multi-function, integral units. Varied surface effects are achieved by texturing, vacuum metalizing, painting or molding in color.

We will welcome the opportunity to assist you in evaluating how "Delrin" can help you improve a product, lower its cost or develop new designs for your profit. A letter or the enclosed coupon will bring a prompt reply.

The head frame (top) of the new "Lady Ronson" Superbe electric shaver is molded of "Delrin", saving 80% of the weight of the previous goldplated die-cast zinc part. Ronson Electric Shaver Corp., Stamford, Conn., specified "Delrin" because only it could be molded to and hold the necessary dimensions, have a smooth luster without finishing and resist body oils and colognes.

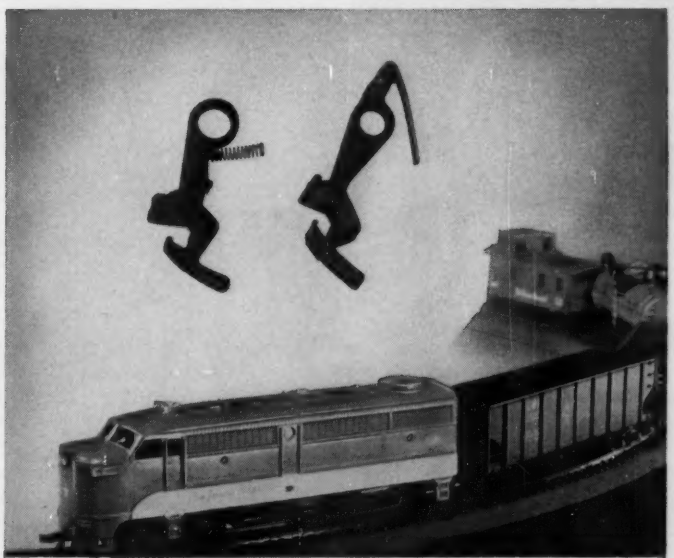


Four parts (in white) of this self-seating faucet are molded of "Delrin", saving 80% of the cost of the machined brass components formerly used by the Kel-Win Manufacturing Co., Inc., Richmond, Va. Kel-Win chose "Delrin" because only it resists corrosion and mineral buildup, remains dimensionally stable and keeps handles comfortable to the touch. Cost savings accrue from the elimination of machining operations and rejects. (Molded by Dominion Plastics Co., Colonial Heights, Va.)

THIS IS WHAT DELRIN® IS DOING

With commercial production of "Delrin" a reality, hundreds of manufacturers are now producing or have specified "Delrin" for such uses as: gears, bearings, housings, aerosol bottles, clothing fitments, pump and valve parts, conveyor belt plates and a host of mechanical components. Three products are described here.

The broad range of the 500 applications of "Delrin" tested during the past three years prompts our belief that "Delrin" may well be profitably used in the products you make or use. Commercial processors and our own staff of technologists are ready to assist you.



The Lionel Corporation, Irvington, N.J., recently introduced a new HO train line featuring a one-piece coupler molded of "Delrin". Because "Delrin" has the resilience to provide the desired springing action, Lionel designed the integral unit to replace a two-part assembly of coupler and coil spring. The result: a significant assembly saving plus a new sales feature. "Delrin" is also used for the axles, journals and two other truck parts. (Molded by Lionel and Gries Reproducer Corp., New Rochelle, N. Y.)

POLYCHEMICALS DEPARTMENT

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living... *through Chemistry*

FOR MORE SPECIFIC INFORMATION MAIL THIS COUPON...

E. I. du Pont de Nemours & Co. (Inc.) Dept. V-414
Rm. 2507D, Nemours Building, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:

_____

NAME_____

COMPANY_____ POSITION_____

STREET_____

CITY_____ STATE_____

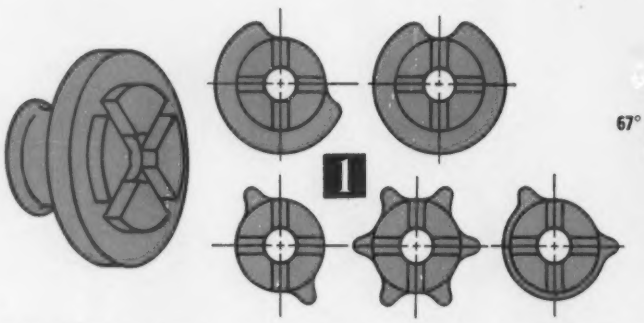
In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec

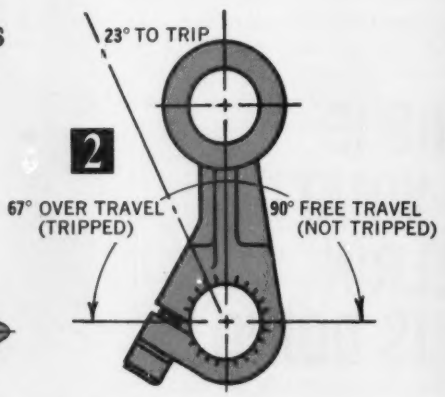
Circle 428 on Page 19

The SL2 snap-lock•Newest NAMCO Machine Life Limit Switch

Snap-Lock Limit Switches, developed by National Acme to meet rigid specifications, have become industry's standard for reliable "machine life" service. Latest and most advanced in the complete line is the SL2. Built with machine tool precision and ruggedness, it will give millions of fast, accurate contacts. Furthermore, it is water and oiltight and can stand the bruising conditions imposed by heavy-duty machine applications. You owe it to yourself to closely examine the *combination* of performance characteristics that assure completely reliable limit switch performance under the most extreme operating conditions.

Closely Check These Outstanding Features





1. Flexible Operation . . . To meet the requirements of any application, standard cam blank (above, left) can be cut into a wide variety of configurations including those shown. Interchangeable, these cams provide positive control of contact sequence; permit tailoring switch performance to individual jobs.

2. Ample Overtravel and By-pass . . . Sixty-seven degree overtravel . . . 90° by-pass . . . 180° arc.

3. Clockwise or counterclockwise motion . . . Converting from clockwise to counterclockwise motion takes but a few seconds.

4. Light Operating Pressure . . . Tripping action requires only 12½ pounds at 1½ inch radius . . . 50% less than previous models. Overtravel reduced so as to require only 8 pounds at 1½ inch radius.

5. Shock-proof Design . . . Positive mechanical lock mechanism withstands shock and vibration.

6. Fast Contact Action . . . High make-and-break contact speed permits use in unusual applications.

7. High Contact Pressure . . . Contact bounce minimized by use of new contact material that permits 15 oz. contact pressure.

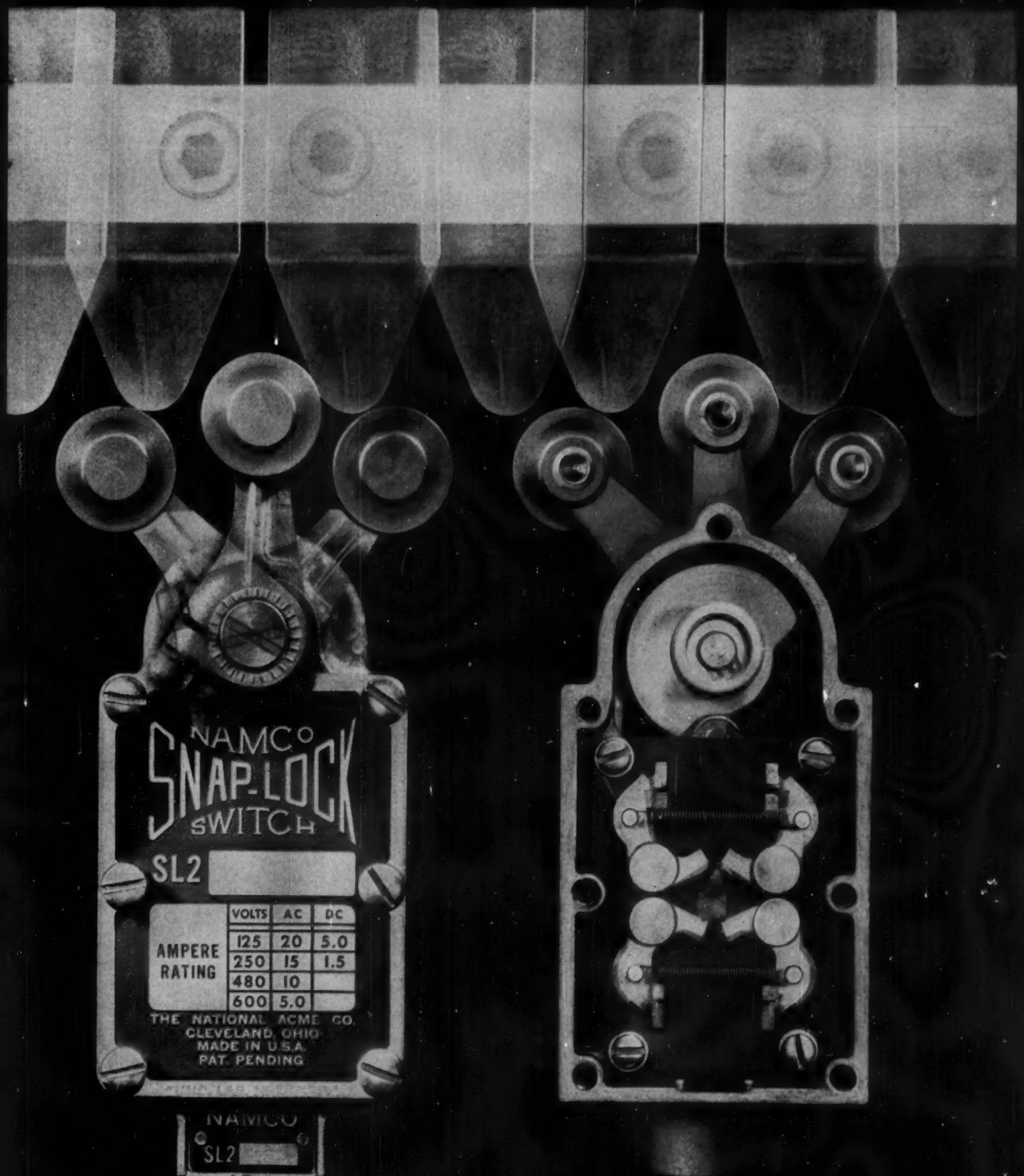
Write for Bulletin EM-SL60 containing complete detailed information

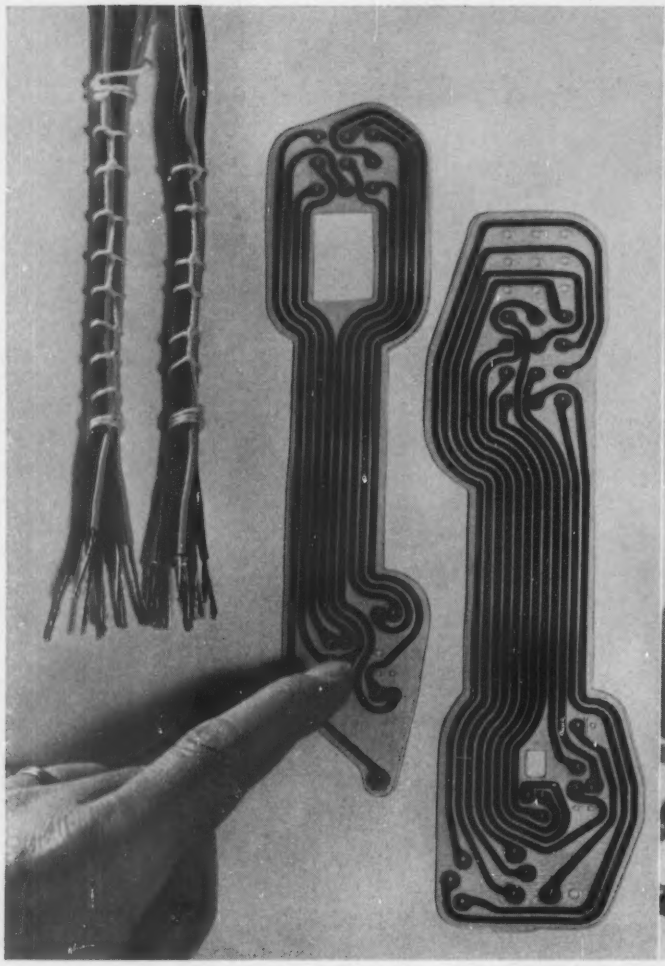
National Acme

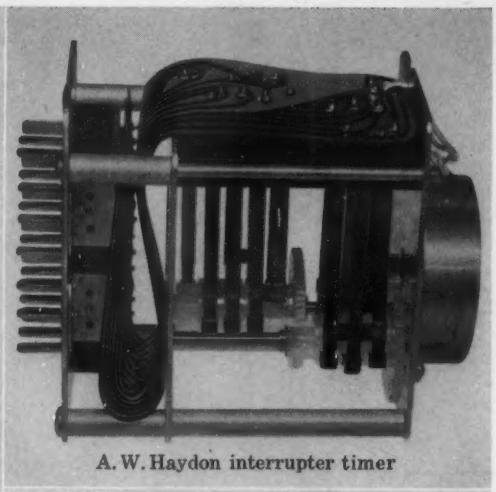
The National Acme Company
188 E. 131st Street
Cleveland 8, Ohio

Sales Offices: Newark 2, N.J.; Chicago 6, Ill.; Detroit 27, Mich.

Circle 429 on Page 19


NAMCO
SNAP-LOCK
SWITCH
SL2
VOLTS AC DC
AMPERE RATING
125 20 5.0
250 15 1.5
480 10
600 5.0
THE NATIONAL ACME CO.
CLEVELAND, OHIO
MADE IN U.S.A.
PAT. PENDING
NAMCO
SL2





A. W. Haydon interrupter timer

Western Electric Call Director telephone

Correct wiring connections made twice as fast!

2 Flexprint® Cables replace 22 wires in A.W.Haydon's interrupter timer...

in one of Western Electric's convenient unattended office telephone systems — utilized by both the familiar push-button control telephones and the exciting new Call Director telephones (shown). The multi-function interrupter timer performs 12 automatic switching functions within the Western Electric system.

The A. W. Haydon Co., Waterbury, Conn. switched from conventional wiring to FLEX-PRINT cables to speed up accurate location of connections and simplify soldering of 44 terminals. Result: *wiring time cut in half.*

Total costs of wiring can be cut as much as 50% when FLEXPRINT circuits replace conventional wiring in electrical and electronic assemblies. Let's see how. Etched and insulated to match your exact requirements, these flat, flexible circuits come in one piece, ready for immediate attachment. No selection of color-coded wires... no cutting to length... no harnesses to lace. Conductors and terminations are accurately positioned for high-speed soldering techniques. 100% reproducibility results in consistently uniform wired assemblies. Costs of quality control testing, trouble-shooting and rework are reduced.

New design engineers' digest describes how FLEXPRINT wiring also fits into product-improvement and miniaturization programs... shows actual Flexprint circuits now in use... suggests new applications... tells you how easy it is to get started with these modern flexible printed circuits. Write for copy:

FLEXPRINT®

® SANDERS ASSOCIATES INC.

PRODUCTS DIVISION
SANDERS ASSOCIATES, INC.
CANAL STREET
NASHUA, NEW HAMPSHIRE
TUxedo 3-3321

Circle 430 on Page 19

Circle 431 on Page 19→

SIMPLE • VERSATILE • UNIQUE

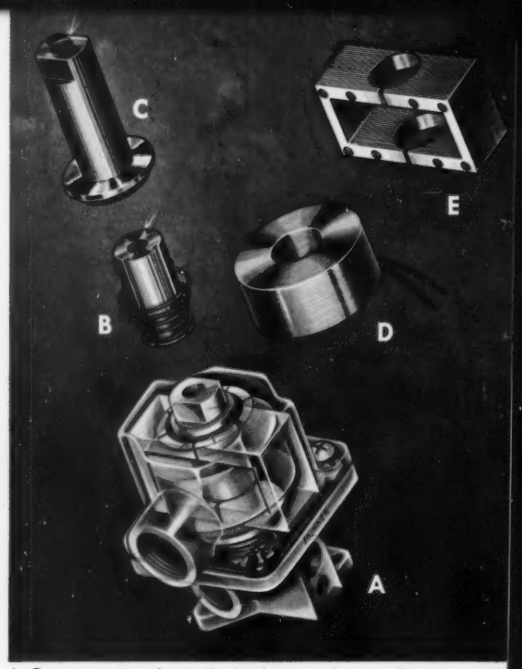
New **SKINNER** 3-way Solenoid Valves

All Skinner Solenoid Valves are...

SIMPLE— Only two moving parts in direct acting valves. Stainless steel internal parts resist corrosion. Soft synthetic inserts provide bubbletight sealing. Most types available in explosion-proof construction.

VERSATILE— Literally thousands of variations are possible—mounting, flow control and porting . . . electrical options in coils, voltages and frequencies . . . types of media, operating temperatures, etc.

UNIQUE— Skinner valve seat does not cut inserts, assures bubbletight sealing and long life. Skinner valve sleeve assembly is precision welded to provide over 5,000 PSI burst strength. Skinner standard valve designs are readily modified for custom applications. From first step in manufacturing to delivery, Skinner quality control and 100 per cent testing builds valves Skinner guarantees for long, trouble-free life.



A—Transparent view of normally closed valve with main orifice shown solid
B—Plunger and spring C—Sleeve D—Coil E—Yoke

SKINNER three-way solenoid valves solve your control system problems

Whatever your problem in controls . . . in machine tool automation, automatic clutching or braking, packaging, instrumentation, laundry equipment, air conditioning, or in any of thousands of applications involving air and hydraulic cylinders or pressurized mechanisms . . . Skinner has the answers.

Skinner design leadership and quality manufacture of solenoid valves has been proved by universally successful use. And as control problems become more complex, Skinner keeps pace with new designs, new valves, and continued top quality production.

The new A series shown above, the new L series, the V5 and V10 series complete the line of Skinner 3-way solenoid valves. Your selection is unlimited.

	V5 Series	V10 Series	A Series	L Series
Orifice sizes	1/32" to 1/4"	3/32"	3/32", 1/8", 5/32"	3/8", 1/8", 3/4"
Pressure Ratings	Up to 200 PSI	1000 PSI	Up to 250 PSI	5 to 150 PSI
Types	Normally open, normally closed, directional control, multi-purpose	Normally open, normally closed, directional control, multi-purpose	Normally open, normally closed, directional control, multi-purpose	Normally open, normally closed, directional control
Construction	Stainless steel body Stainless steel internal parts	Stainless steel body Stainless steel internal parts	Zinc die-cast body Stainless steel internal parts	Forged naval brass body Stainless steel and brass internal parts
Body Pipe Connector	1/8 and 1/4 NPT	1/8 NPT	1/4 NPTF	3/8", 1/2", 3/4" NPTF

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at the address below.

SKINNER ELECTRIC VALVES

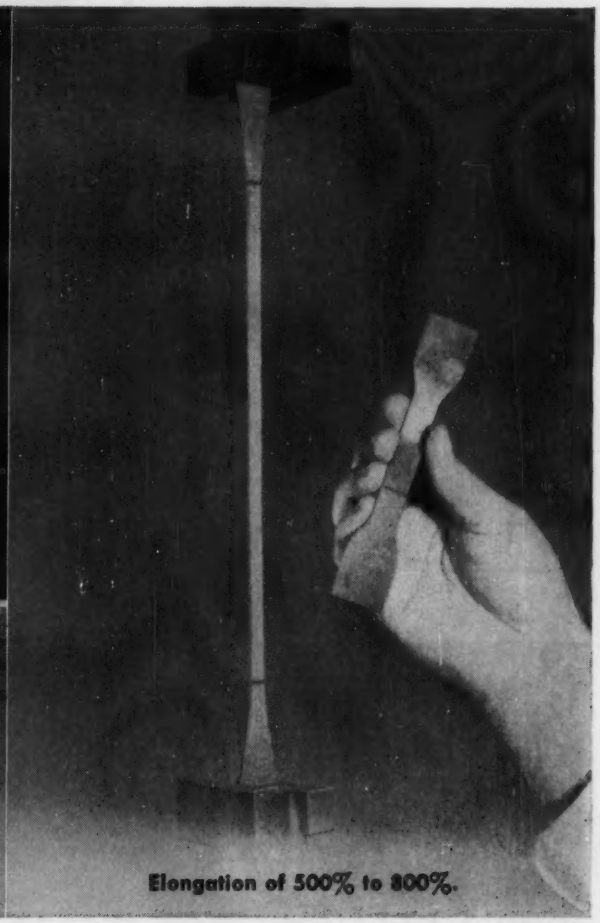
THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION,
THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT

PRINTED IN U.S.A.

HARDNESS *plus* ELASTICITY

So tough it can drive spikes into wood without damage to mallet head, yet so resilient a similar blow will not mar a polished table top!



Elongation of 500% to 800%.

a "combination" property of Urethane Elastomers

The use of urethane elastomers for cast gears, inserts and similar parts permits a wide range of tolerance in design with resultant economies in manufacture. Their high elasticity allows minor misalignments and imperfect fitting prohibitive in all-metal construction. For example, flexible couplings with connector discs of solid urethane permit up to 0.040 in. linear and 12° angular misalignment without malfunction.

Similar design freedom is possible with many applications where high hardness, tensile strength, abrasion and solvent resistance, and toughness are critical requirements. Parts designed for screw-on, snap or compression fitting, fastening with bosses, dovetails or grommets, may all be cast in simple, inexpensive molds at production-line speed.

For optimum properties and performance, be sure to specify elastomers made of Multrathane® chemicals. Write Mobay for technical literature and a list of licensed elastomer fabricators.

Other Combination Properties of Multrathane-based elastomers:

- **WEAR RESISTANCE**—Combination of high tensile strength, abrasion resistance and tear strength.
- **CONTROLLED FRICTION**—High or low coefficient of friction through compounding.
- **SOLVENT RESISTANCE**—Oil immersion at 130°C. for 100 hours with negligible loss of properties.
- **AGING RESISTANCE**—Excellent resistance to ozone, oxygen and weathering.
- **SHOCK ABSORPTION**—High load-bearing, vibration dampening and shock absorbing properties.

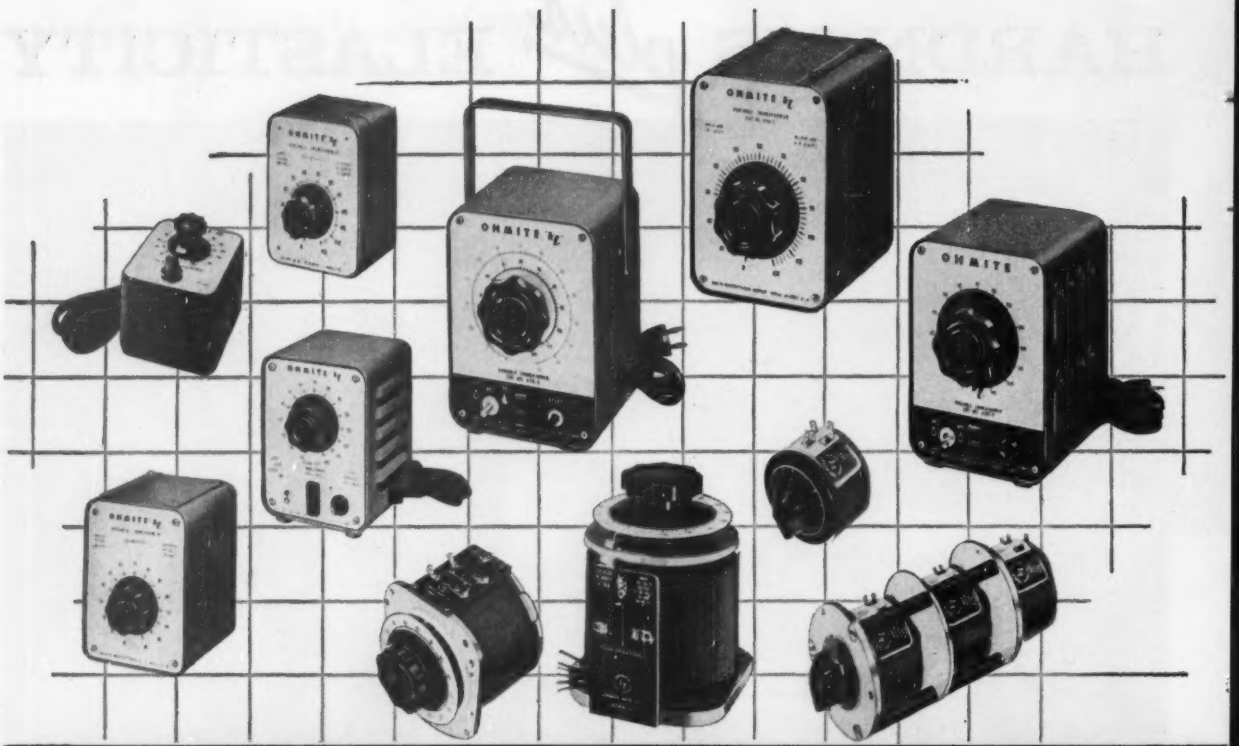
MOBAY CHEMICAL COMPANY
Dept. H-3 Penn Lincoln Parkway West
Pittsburgh 5, Pennsylvania e-2

Mobay supplies Multrathane chemicals and technology for manufacturing urethane elastomers.

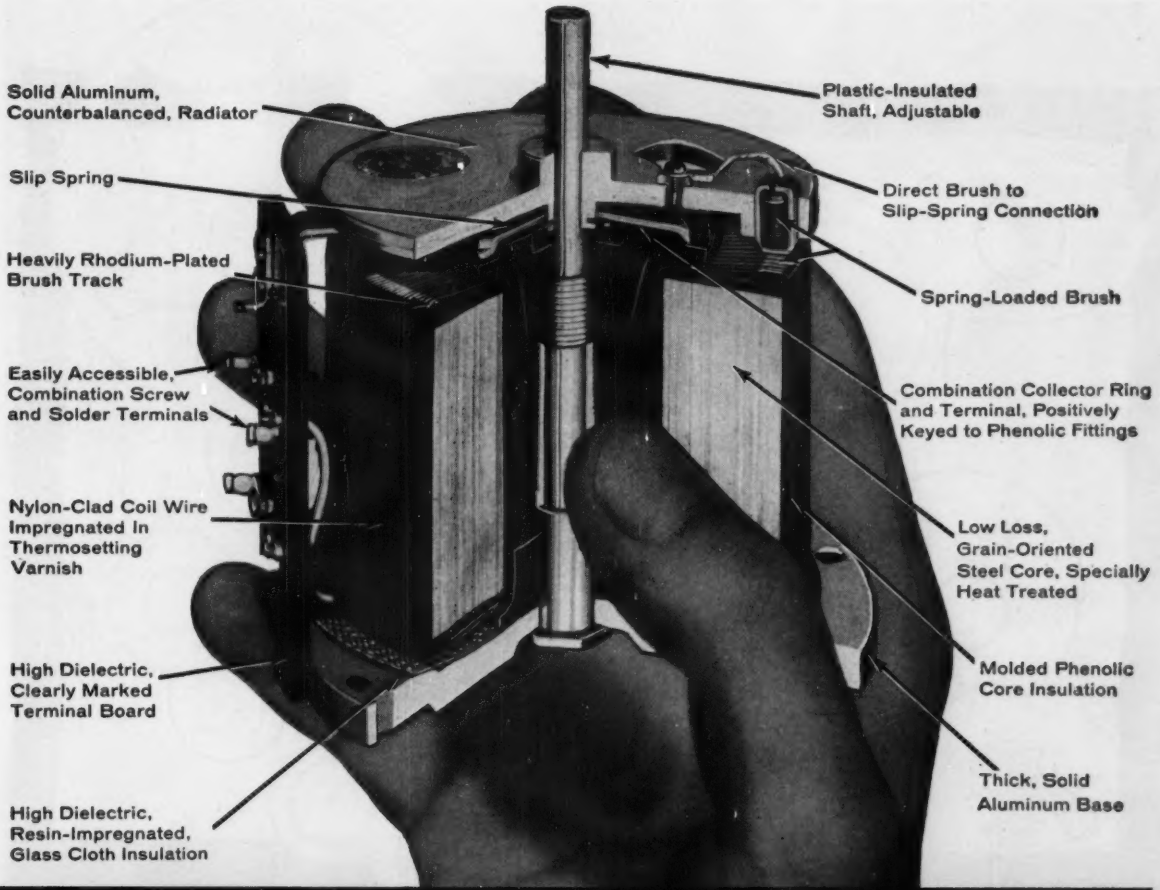
MOBAY
First in Urethane Chemistry

←Circle 431 on Page 19

Circle 432 on Page 19



Select from the Line with ADVANCED DESIGN


Solid Aluminum, Counterbalanced, Radiator
Slip Spring
Heavily Rhodium-Plated Brush Track
Easily Accessible, Combination Screw and Solder Terminals
Nylon-Clad Coil Wire Impregnated In Thermosetting Varnish
High Dielectric, Clearly Marked Terminal Board
High Dielectric, Resin-Impregnated, Glass Cloth Insulation
Plastic-Insulated Shaft, Adjustable
Direct Brush to Slip-Spring Connection
Spring-Loaded Brush
Combination Collector Ring and Terminal, Positively Keyed to Phenolic Fittings
Low Loss, Grain-Oriented Steel Core, Specially Heat Treated
Molded Phenolic Core Insulation
Thick, Solid Aluminum Base

OHMITE® *v.t.* VARIABLE TRANSFORMERS

By combining a fresh approach in design with traditional Ohmite quality, "v.t." variable transformers offer convenience features and performance not found elsewhere. They offer top efficiency and high output for their size. Through Ohmite's engineering design, a sizeable bonus in output is available in the "no-overvoltage" types where voltages above line voltage are not required. These units deliver rated output current at *any* brush setting . . . freedom from wave-form distortion . . . excellent regulation at any point within the rated load . . . unusually long life . . . smooth, maintenance-free operation. They are interchangeable with other makes. Adjustable shafts permit ready conversion to table or panel mounting. Offered in a diversified choice of cased models.

Moreover, you can get fast delivery from stock on 35 different models covering ratings up to 10 amps. Or, if you desire, select your special requirements from the many modifications possible. Among these are special windings, custom enclosures (including "explosion-proof"), motor-driven assemblies, auxiliary switches, numerous shaft styles, special tandem units, and combination assemblies with other components.

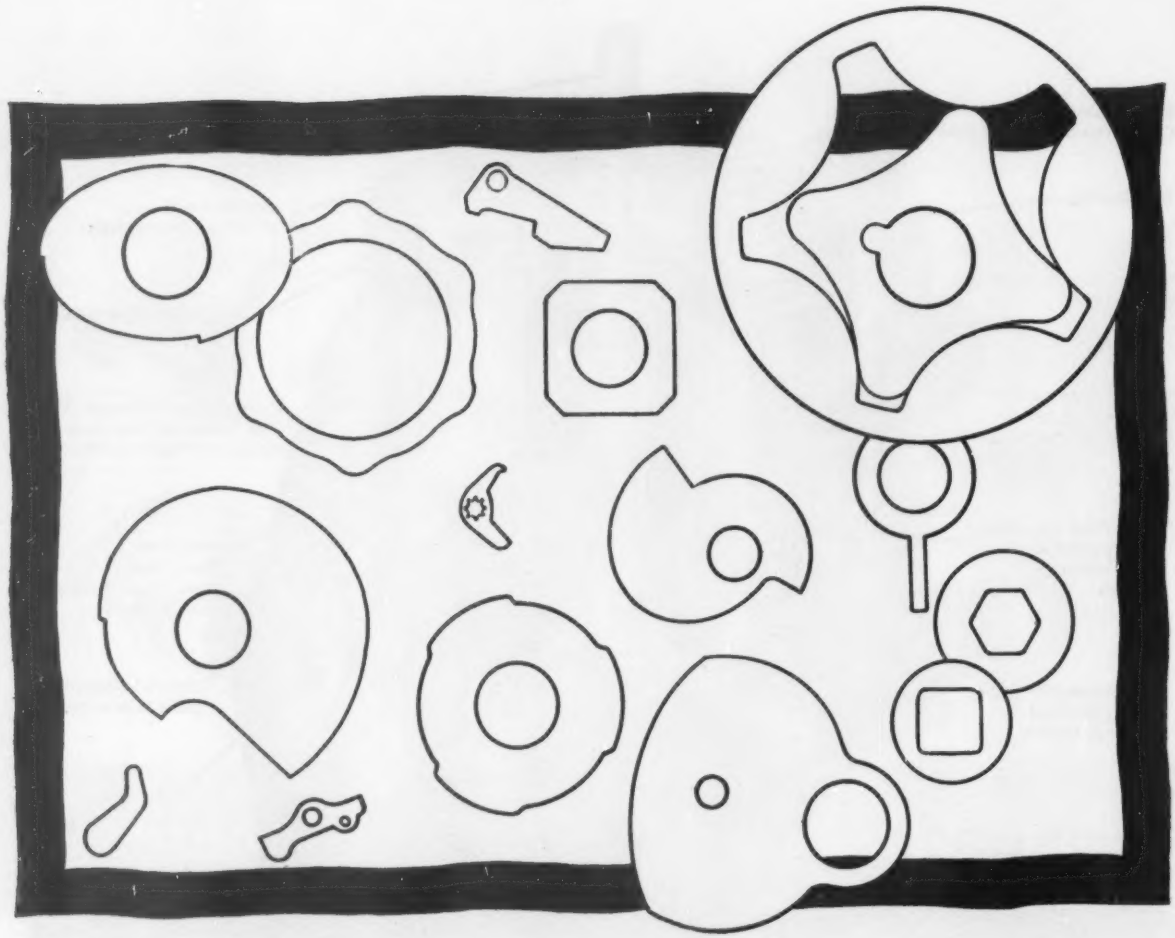
On your next order for variable transformers, try the line with *advanced design*—Ohmite.

Be Right with OHMITE® Quality Components

Write for Bulletin 151

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois
RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES
R.F. CHOKES • VARIABLE TRANSFORMERS
TANTALUM CAPACITORS • GERMANIUM DIODES

Circle 433 on Page 19



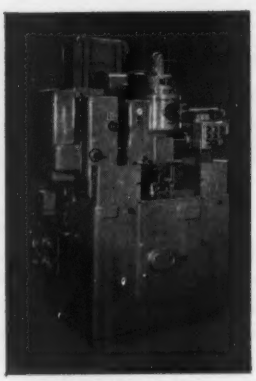
NOT ALL GEAR SHAPERS CUT GEARS

. . . a lot of them are in production, cutting parts having non-involute shapes of various kinds. Many designers take full advantage of the versatility of the Gear Shaper by designing odd-shaped parts that can be easily and economically generated by merely using special Fellows cutters and fixtures on their standard Fellows machines.

The almost unlimited variety of work includes square and elliptical shapes, cams, pawls, pump rotors, etc., both internal and external.

Remember this *plus* value which helps guarantee a full, profitable work load on your Fellows generating equipment.

"The Art of Generating with a Reciprocating Tool", a fact-packed 48-page catalog, gives details on this versatile production technique. May we send you a free copy?



No. 4GS Fellows Gear Shaper

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U.S.A.
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N.J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE

Fellows *Gear Production Equipment*

Circle 434 on Page 19

Mt. Vernon reduces 5 castings to 2 in the new Black & Decker Polisher

CASE HISTORIES FROM MT. VERNON FILES

Subject:

The Black & Decker Manufacturing Company, TOWSON, MARYLAND

This new B & D "Servicemaster" Polisher—and its companion Sander, each of which sells for only $65. —contains outstanding features formerly found only in higher priced units: heavy-duty ball bearings; spiral bevel gears; recessed toggle switch, protected from dust; rugged lightweight aluminum housings.

Advanced design, which took into consideration most of the inherent advantages of high-pressure aluminum die casting, resulted in considerable manufacturing economies and an ultimate *low price tag.*

Conventional design on the regular B & D line uses 5 castings: 1-a gear case 2-a gear case cover 3-a main field case 4-a switch handle 5-a switch handle cover. In the new B & D design concept *5 parts have been combined into 2 clam-shell castings* which weigh only 2 pounds 3 ounces, a weight reduction of approximately 2 pounds over similar type polishers... the new complete "Servicemaster" polisher weighs only 8¼ pounds.

Fewer parts, however complex, mean reduction in secondary assembly operations. But despite intricate design... the superior skill of Mt. Vernon craftsmen has assured Black & Decker a steady supply of highest quality aluminum castings, economical, excellent fitting... excellently finished... requiring the least number of finishing operations.

Perhaps, like Black & Decker, you too have a cost problem. Product design with our assistance may be your answer. Let's talk it over. Just call your nearest Mt. Vernon sales representative for action.

MT. VERNON DIE CASTING CORPORATION
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

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BROOKLYN, N. Y.: Mr. Robert V. Moore, 2317 Plumb 2nd St.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
GUILDERLAND, N. Y.: Mr. David H. King, 75 Willow St.
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QUINCY, MASS.: Mr. Edmund W. Libby, 91 Merrymount Rd.
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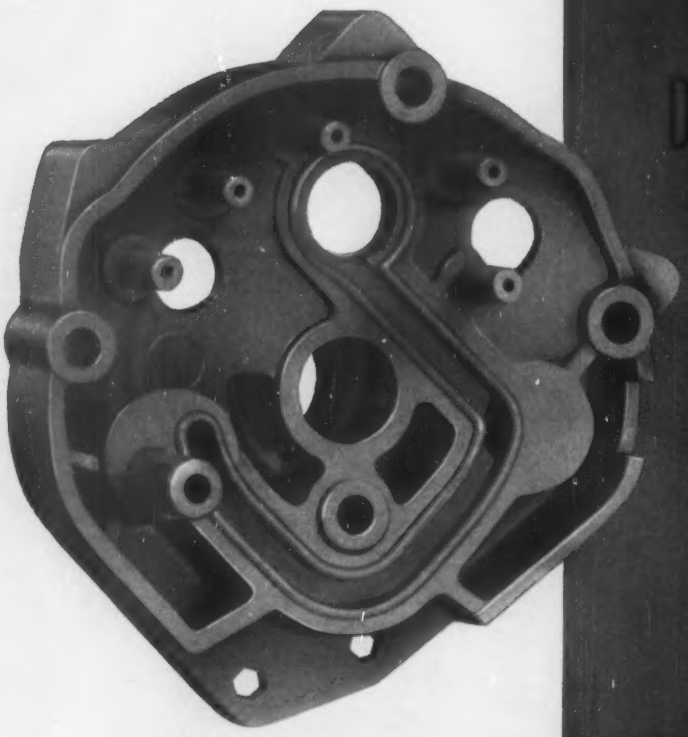
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115



Designing Excess Labor Out of your product with MADISON-KIPP zinc and aluminum die castings

In the DOLE VALVE COMPANY'S AUTOMOTIVE VACUUM SERVO CONTROL HEAD the intricate shape, the tubes, the gasket grooves and holes are all cast to size.

This is a prime example of maximum utilization of the die casting process.

The skilled and cost-conscious mechanics at Madison-Kipp worked closely with the valve designer to create a component of excellence and low secondary labor content.

Please clip this ad as a reminder to contact us when you have die casting requirements.

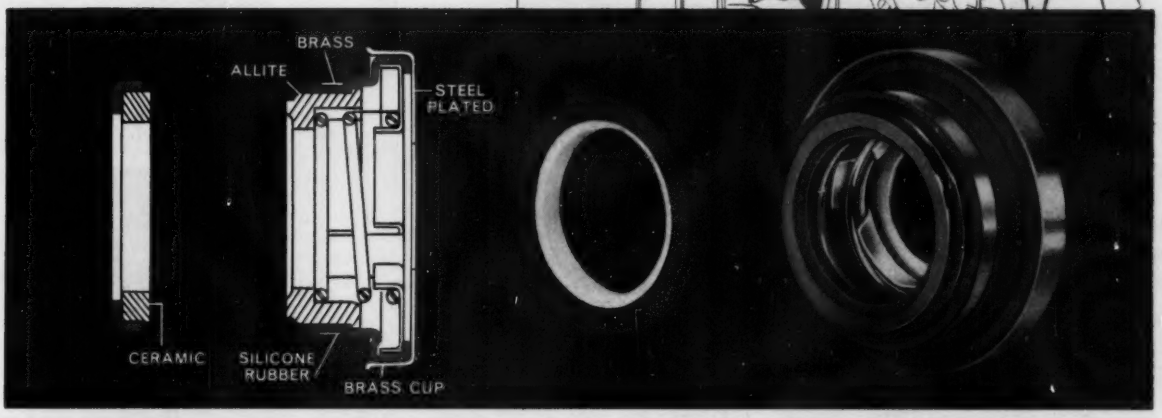
MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WISCONSIN U.S.A.

- Skilled in Die Casting Mechanics
- Experienced in Lubrication Engineering
- Originators of Really High Speed Air Tools

kipp

Circle 436 on Page 19

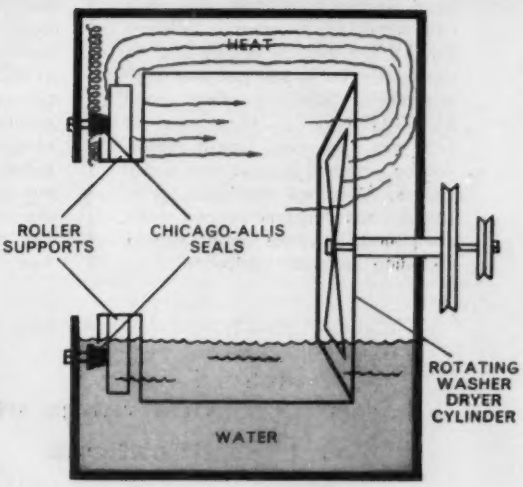
Happy wash days depend on round the clock sealing action



CHICAGO-ALLIS SEAL DESIGN RESISTS HEAT, WATER, SOAP, DETERGENTS AND DIRT... SEALS GREASE IN ROLLER BEARINGS FOREVER

When assigned the engineering task of designing a lifetime seal for a nationally known washer-dryer machine product, Chicago-Allis came up with the right answer pronto. The C-A seal protects bearings in rubber rollers which support the rotary washer-dryer cylinder. Rubber component parts in the C-A seal are molded of silicone and resist heat up to 240° F. Spring loading of the surface sealing elements (Allite and Ceramic), creates a life-long water and grease tight seal.

A typical example of how Chicago-Allis meets specialized needs in mechanical seals and custom molded rubber parts.



Four mechanical seals are used in this washer-dryer application—two of which must operate *under water* during the washing cycle, and all are exposed to extreme heat during the drying cycle.

See us at 1960 Design Engineering Show New York City, May 23-26

Send for complete information on all Chicago-Allis products and services.

"Chicago-Allis Engineers to your Specifications"

SINCE 1889

CHICAGO-ALLIS MFG. CORP.

Producers of CHICAGO BELTING · ALLIS RUBBER · ALLIS SEAL Products

127 NORTH GREEN ST. · CHICAGO 7, ILLINOIS

Engineers · Designers · Manufacturers

Circle 437 on Page 19

The POWER behind the leading products

3500 STANDARD

built-to-order Bodine Motors!

300 STOCK Bodine Motors!

FOR office machines, instruments, timing devices, pumps, coin-handling equipment, communication equipment, therapeutic devices, sound-recording and reproducing equipment, machine tools, plus many other applications.

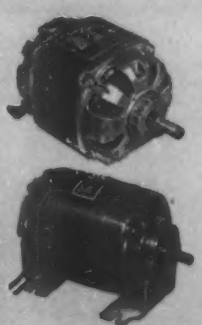
TYPE N MOTORS:
Bodine Type N Motors are manufactured in three basic sizes, with each size available in several different lengths. The smallest is only 3⅜" in diameter...the largest just over 5½" in diameter. Standard ratings range from 1/150 to 1/6 horsepower at 1725 rpm...however, Type N Motors can be furnished in other ratings and speeds. Windings available: split-phase, capacitor, synchronous, shunt, compound, universal (series wound, including governor controlled).

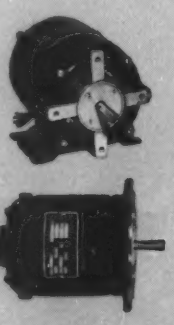
TYPE K-2 MOTORS:
The K-2, which is one of the smallest distributed wound motors manufactured today, is only 2⅜" high. Normal 60 cycle output ranges from 1/2000 to 1/500 horsepower on continuous duty. Power is substantially greater than motors of clock type construction. These motors are well suited for applications, such as timing devices, instruments, and related equipment which calls for relatively low output, and continuous trouble-free service.

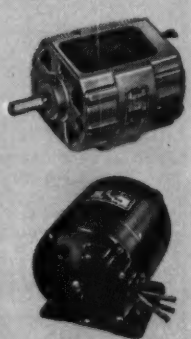
TYPE V-10 MOTORS:
Supplied with a series winding, the V-10 has variable speed characteristics, and a full load speed of 5000 rpm. It has a high starting torque and rapid acceleration, and can be operated on either DC or AC. This is a compact motor and offers generous power with light weight and small enclosure. Three tapped holes in the end shield allow end mounting. Optional horizontal base mounting requires a motor frame strap.

300 Different Stock Type of Motors Available Immediately from Distributors Located in Major Manufacturing Areas

AND a wide range of special purpose motors and modifications







Small Speed Reducer Motors in over 1600 standard specifications!

Motors with built-in speed reducers are used extensively by manufacturers of motor-driven machines, who desire a compact, low-speed motor. By combining the motor and speed reducer in one unit, all cumbersome and complicated speed reducer transmissions, such as belts, gears, and chains are eliminated. Design and installation time are saved. The unit is compact, quiet, and attractive in appearance. Trouble-free performance is assured.

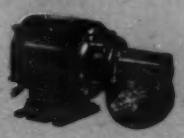
TORQUES
1.3 in. oz. to 350 in. lb.

SPEEDS
0.6 to 300 rpm.

RATIOS
6:1 to 2880:1

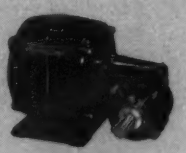
Group 1...Speed reducer motors designed for transmitting low torques over a wide range of speeds. Motor diameter about 2¾" to 3⅜". Worm of hardened, long-wearing, nitralloy steel cut on motor shaft (except for the low powered V-10R and NSP-11R). Laminated bakelite primary gear. Secondary gear, bronze on ratios 180:1 or more; laminated bakelite on lower ratios. Ratios—Single Reduction Ratios—6:1 to 30:1 Double Reduction Ratios—36:1 to 1120:1.

Group 2...A double worm-gear speed reducer designed to deliver moderate (up to 52 in. lbs.) torques at low speeds. Diameter of motor approximately 3⅜". Both primary and secondary worms are of hardened nitralloy steel. Laminated bakelite primary gear. Hard bronze secondary gear. Motor shaft has prelubricated ball bearings. Secondary and driveshafts have bronze sleeve bearings, grease lubricated. Reduction ratios—60:1 to 1350:1.



Group 3...A single reduction right-angle worm-gear reducer, designed for transmitting moderate (up to 21 in. lbs.) torques. Diameter of motor approximately 3⅜" to 4⅜". Separable hardened and ground steel worm. Laminated bakelite gear on steel hub. Motor shaft has ball bearings with built-in grease seals. Ratios —10:1 to 60:1. Motor Mounting—Any position except with gear housing above motor.

Group 4...A double worm-gear reducer for transmitting high (up to 219 in. lbs.) torques at low speeds. Motor diameter approximately 4⅜". Worms are accurately ground from hardened steel. The bakelite primary gear assures quietness; the hard bronze secondary gear provides long life. Ball bearings used throughout. Reduction ratios range from 72:1 to 2880:1. Any specified mounting position may be obtained except gear head over motor.



Group 5...A single reduction, right-angle worm-gear reducer, capable of transmitting substantial (up to 73 in. lbs.) torques. Motor diameter 4⅜" to 5⅜". Separable hardened and ground steel worm. Gears of laminated bakelite or hard gear bronze, depending on torques delivered. Motor shaft has ball bearings, grease-lubricated with self-seals. Ratios—10:1 to 60:1.

Group 7...Extra rugged reducer for driving heavy (up to 198 in. lbs.) loads continuously with ample reserve for overloads. Loads are carried on ball bearings. All forces directly transmitted to the motor feet. Separable steel worms are hardened and ground. Gear is of bronze. Ratios—8:1 to 48:1. Motor may be assembled to mount in any position except gear head over motor.

BODINE
fractional / horsepower
MOTORS

BODINE

BODINE ELECTRIC COMPANY
2508 West Bradley Place Chicago 18, Illinois

FREE
12-page technical bulletin

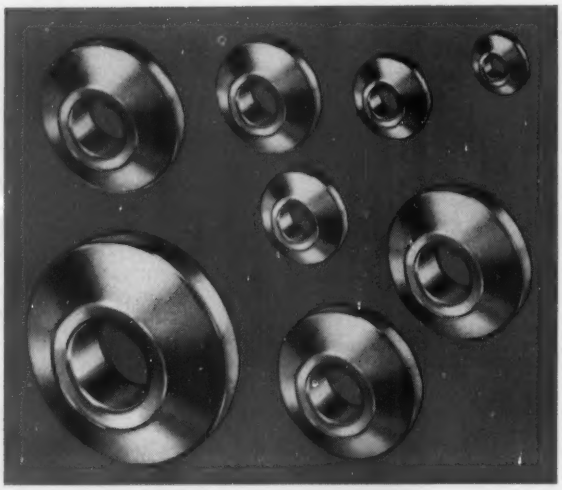
Additional detailed information on the more widely used Bodine Motors is contained in newly revised bulletin S-2. Copies available on request.

K-2 Speed reducer motor designed for continuous duty applications requiring sturdy construction and exceptional reliability. Small, rugged. Available with built-in spur or helical gearing. Synchronous or nonsynchronous. Distributed windings are used for highest efficiency. Speeds 300 rpm. to 0.7 rpm. Torque 1.3 to 120 inch ounces. Frame-die cast zinc except for the steel laminations. Ball bearings are standard. Ratios—6:1 to 1800:1. Capacitor is included with each motor.

35 MILLION BEARINGS...

and every one has given perfect performance!

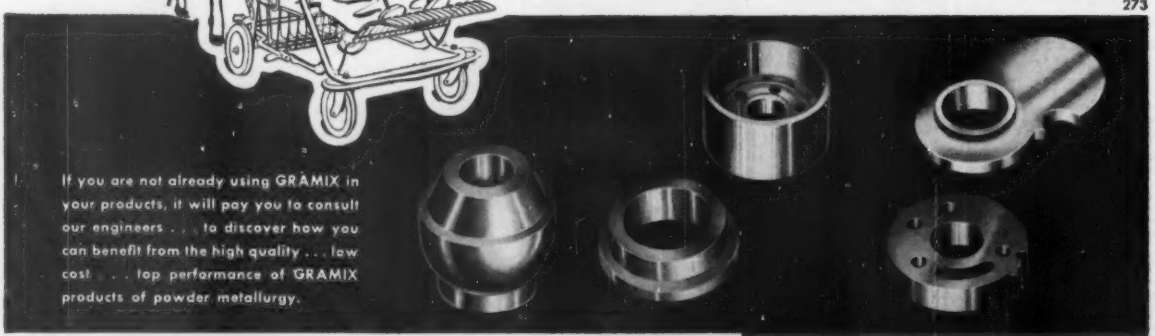
that's the record of GRAMIX® bearings in the famous TAYLOR-TOT® SLEEPER WALKER-STROLLER



Where there are youngsters, there are Taylor-Tots . . . and where there are these familiar sleeper walker-strollers there are GRAMIX bearings . . . in fact, 35 million to date have been shipped to the Frank F. Taylor Company of Cincinnati and have been accepted by their receiving inspection department without a single rejection. The strength, durability and resistance to wear of these GRAMIX bearings, two of which are used in each wheel, help give Taylor-Tot easier steering and handling. Even though Taylor-Tot strollers are run through snow, dirt and many times are left out in adverse weather, GRAMIX bearings provide the maximum in quietness, free running and long life.

GRAMIX is the ideal bearing material because it can be oil-impregnated for self-lubrication, requires no machining and is completely dependable.

273



If you are not already using GRAMIX in your products, it will pay you to consult our engineers . . . to discover how you can benefit from the high quality . . . low cost . . . top performance of GRAMIX products of powder metallurgy.

Write today for Engineering Bulletin No. 18, which covers design and metallurgical requirements and alloy selection of GRAMIX bearings. ▶

THE UNITED STATES GRAPHITE COMPANY

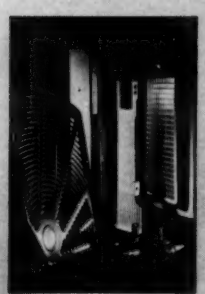
DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Circle 439 on Page 19

Circle 440 on Page 19→

WE BREAK BOTTLENECKS



Jervis quality metal stampings are supplied to the automotive, appliance hardware, and marine hardware industries.

Contact Jervis and add eight acres of high-volume metal stamping equipment to your production line. Sixty presses, ranging in capacity from five tons to two thousand tons, are only a part of the Jervis set-up. Die space on these presses goes up to thirty-six inches. Bed area is as high as sixty inches by sixty inches. Buy quality metal stampings. Bring your specifications or blueprints to Jervis for an estimate that will break your production bottleneck. For complete information about Jervis operations (stamping, casting, finishing, assembly), write for free color brochure "This is Jervis." JERVIS CORPORATION, Grandville, Michigan.

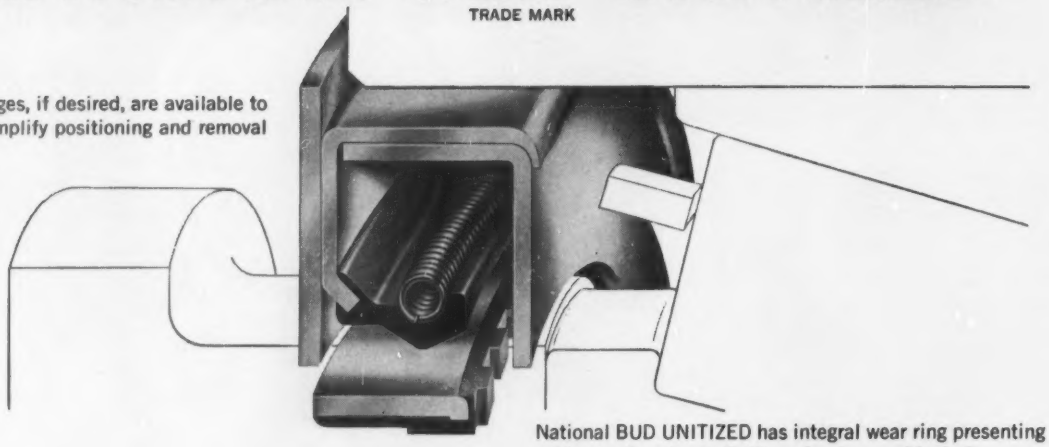
JC JERVIS CORPORATION

NATIONAL® OIL SEAL LOGBOOK

Presenting!

NATIONAL BUD UNITIZED

TRADE MARK



National BUD UNITIZED has integral wear ring presenting rubber surface to shaft. Wear ring turns with shaft, sealing lip is never exposed to damage, cannot score shaft.

A new unitized oil-seal-and-wear ring that eliminates:

SHAFT WEAR OR SCORING

SEPARATE METAL WEAR SLEEVES

EXPENSIVE SHAFT FINISHES

COSTLY SHAFT RE-MACHINING

SEALING LIP INSTALLATION DAMAGE

SPECIAL INSTALLATION PROCEDURES

New National BUD UNITIZED seals are now in production, in a limited range of sizes, for heavy oil and grease sealing applications — including truck, bus and tractor uses. Still newer BUD UNITIZED seals are on the way for higher speed automotive and similar uses.

Changing a National BUD UNITIZED oil seal automatically changes the wear sleeve — in one fast, simple operation. Since the seal has its own integral wear ring, it is almost impossible to install it other than squarely on the shaft. Expensive shaft finishing is no longer a necessity, nor is leakage under a metal wear ring a problem — both thanks to the rubber surface BUD UNITIZED presents to the shaft.

For complete details or skilled engineering help on application of BUD UNITIZED seals, write direct, or call your National Seal Applications Engineer. You'll find him in the Yellow Pages, under Oil Seals.

NATIONAL SEAL

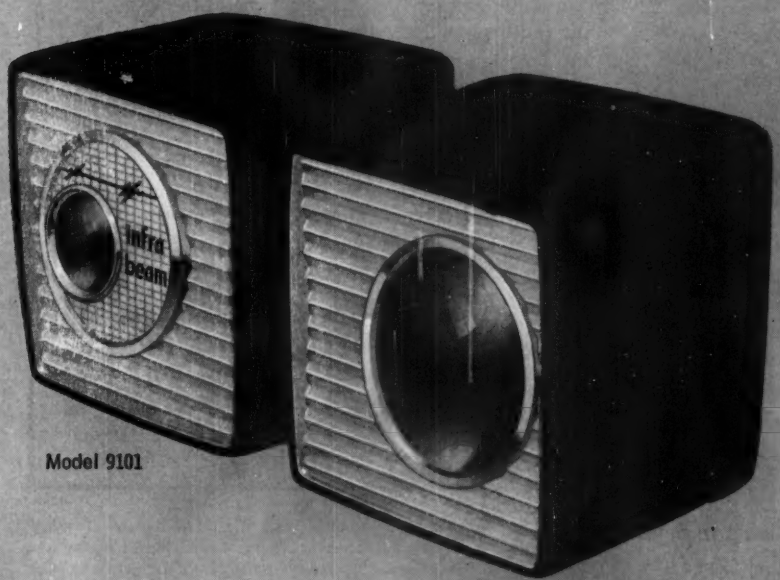
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City and Downey, California

6013-R

Announcing

Infrabeam

... the revolutionary photoelectric control using modulated infrared radiation



Model 9101

FOR THE FIRST TIME, photoelectric control is *simple, reliable,* and *practical* over an extremely wide range of applications.

Infrabeam is a totally new type of photoelectric control . . . developed and tested over a period of more than a year, now ready to go to work in your plant or as part of equipment you manufacture. It offers a combination of simplicity, sensitiveness and reliability that has never before been achieved.

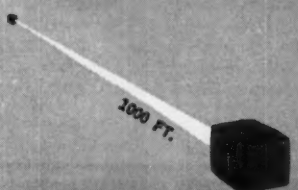
New infrared detectors, perfected for missile guidance, are in many ways superior to photocells that respond to visible or ultraviolet light. In Infrabeam, the Receiver contains a similar infrared detector which is screened against visible light by a simple optical filter. Further, the infrared beam from the Projector is "modulated" — brightening and dimming at a frequency of 400 cycles per second. The Receiver is electronically tuned to this frequency, so that the control will not respond unless it gets a signal from the associated Projector.

WHAT THIS MEANS TO YOU...

Compared with standard "general purpose" photoelectric controls, Infrabeam provides far greater sensitiveness in countless applications at close or moderate range. At extreme range — as much as 1000 feet — it offers superior reliability and freedom from interference. Because it operates equally well by reflecting the infrared beam from a detected object and into the Receiver, it is the *only* photoelectric control able to reach into "blind" areas with perfect freedom of installation.

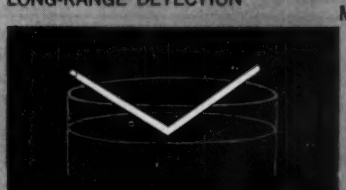
Projector and Receiver are attractively housed in anodized cast aluminum. The quick-detach hinge allows easy separation for use as opposed units, or accurate angling for use in reflection. Physical mounting and electrical connections are simplicity itself, and permit quick replacement of either unit without disturbing permanent wiring.

Find out how simple and practical photoelectric control can be for *you.* WRITE TODAY FOR COMPLETE DETAILS AND SPECIFICATIONS.



LONG-RANGE DETECTION

MACHINE CONTROL



LIQUID LEVEL CONTROL

INSPECTION OR SORTING

CONVEYOR CONTROL

ELECTRONICS DIVISION

CRAMER CONTROLS

CORPORATION

CENTERBROOK, CONNECTICUT

Circle 442 on Page 19

NOW AVAILABLE!

P-K® SOCKET SCREWS WITH LONG-LOK® INSERTS

Provides high resistance to shock and vibration.

Assures superior thread engagement and locking force.

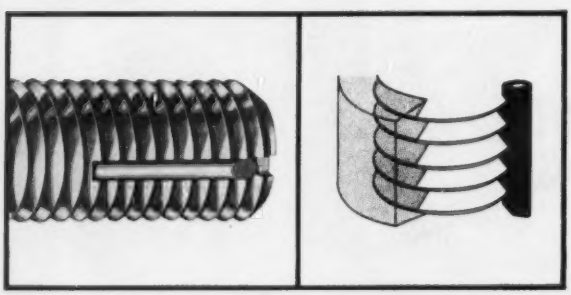
Permits high reusability.

Eliminates lock washers and safety wire.

WHAT IS LONG-LOK?

Long-Lok is an insert which becomes an integral part of the P-K Socket Screw in which it is used. A root-deep axial slot is milled into the external threads of any of the various types of P-K Socket Screws and permanently filled with a specific material engineered for the design application. In use, the insert provides triple locking action: (a) axial tolerance is taken up by the resilient insert material, causing metal-to-metal "drag", (b) radial tolerance is taken up because the side opposite the insert is forced into close contact for additional metal-to-metal "drag", and (c) torsional resistance of the insert itself.

The fastener is easily inserted and started because of the tapered end of the insert. The length of the insert assures full engagement of the locking material and a radial load on mated threads.



In locking and anchoring applications, the insert assures a radial load on mated threads which results in increased contact friction at the thread flanks. Under operating conditions, the friction then prevents relative motion between the mating threaded parts. In sealing applications, the insert is selected and processed to result in a dam which prevents the flow of gas or liquid along the thread helix. Axial of a fluid or gas is prevented by a uniform annular flank-to-flank contact of the mating thread pitches.

HERE ARE SOME OF THE ADVANTAGES!

P-K Socket Screws with Long-Lok Inserts speed-up and improve reliability of assembly operations. The P-K Socket Screw with Long-Lok is not dependent upon seating operations, locking securely wherever installation torque stops. Long-Lok inserts span temperature ranges from –320°F to +1200°F as required; pass through normal clearance hole with ease and install easily because torque forces build up smoothly and gradually all the way.

The Long-Lok insert does not protrude, thus P-K Socket Screws with Long-Lok inserts pass through normal clearance holes with finger pressure. No special clearance holes are required. Normal handling or installation will not dislodge inserts.

P-K Socket Screws with Long-Lok inserts make possible a long range of adjustment, and because of the extremely low "cold flow" and exceptional "memory" of the insert material, insure a high degree of reusability. Insert material does not project beyond the basic diameter of the fastener and the slot does not present an abrupt change of section to operating loads. What's more, the small cross sectional area of the insert has no effect upon fatigue strength and does not reduce basic rated tensile strength of the unit.

WHERE SHOULD LONG-LOK BE USED?

In industrial and consumer products—tools, machines, appliances—wherever vibration is present—wherever adjustment may be required—wherever re-use is a factor—wherever the needs of quality control in production are exacting . . . P-K Long-Lok fasteners may be the right answer. In the electronics industry, in engines, hydraulics, valves, optical instruments—even in guided missiles—Long-Lok is building an enviable reputation for reliability.

TIME AND COST REDUCTION

Critical weight and needless man-hours of assembly time can be saved through the use of P-K Socket Screws with Long-Lok inserts. The fasteners are heat, impact, shock and vibration resistant. They completely eliminate the need for intricate and costly safety-wire installations.

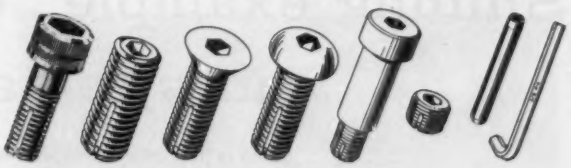
In the aircraft industry, fasteners with Long-Lok inserts are an exciting advance—opening up new, faster, safer design opportunities—doing away with costly, intricate safety-wiring operations—resulting in fastenings that stay tight and secure under punishing vibration—under every environmental attack. Long-Lok fasteners are already in use in supersonic applications and meet the requirements of #MIL F 18240A (ASG) and NAS1081 specifications.

In the automotive industry, P-K Socket Screws with Long-Lok inserts will meet every requirement for efficiency and reliability. As an adjustment screw, this new fastener can offer superior performance and in many cases the efficiency of the insert can act as a barrier against fluid leakage, eliminating the need for messy sealing compounds.

HOW IS THE LONG-LOK FURNISHED?

Parker-Kalon Socket Screws with Long-Lok inserts are available in socket head cap screws, set screws, flat head, button head, shoulder screws and pipe plugs. They will be stocked by your P-K Distributor in a range of popular sizes with Polycap (green) inserts. Polycap is a nylon type polymer capable of performing within a temperature range of −120°F to +250°F and recommended for general applications, thread-sealing applications and applications requiring frequent adjustment.

On order, Parker-Kalon will supply Socket Screws with Long-Lok BLUE-KEL-F® inserts, a thermoplastic with zero water absorption for −120F° to −320°F, and for +250°F to +390°F. For use where temperature requirements range between +400°F and +1200°F, Parker-Kalon will furnish Socket Screws with Long-Lok metallic inserts.



A COMPLETE LINE

Parker-Kalon offers a complete line of Socket Head Cap Screws, Shoulder Screws, Button Heads, Flat Heads, Set Screws, Hex Keys and Key Kits, Dowel Pins and Pipe Plugs, as well as the P-K Pre-Lode (1960 Series) Socket Head Cap Screw and the revolutionary new P-K W-Point Socket Set Screw.

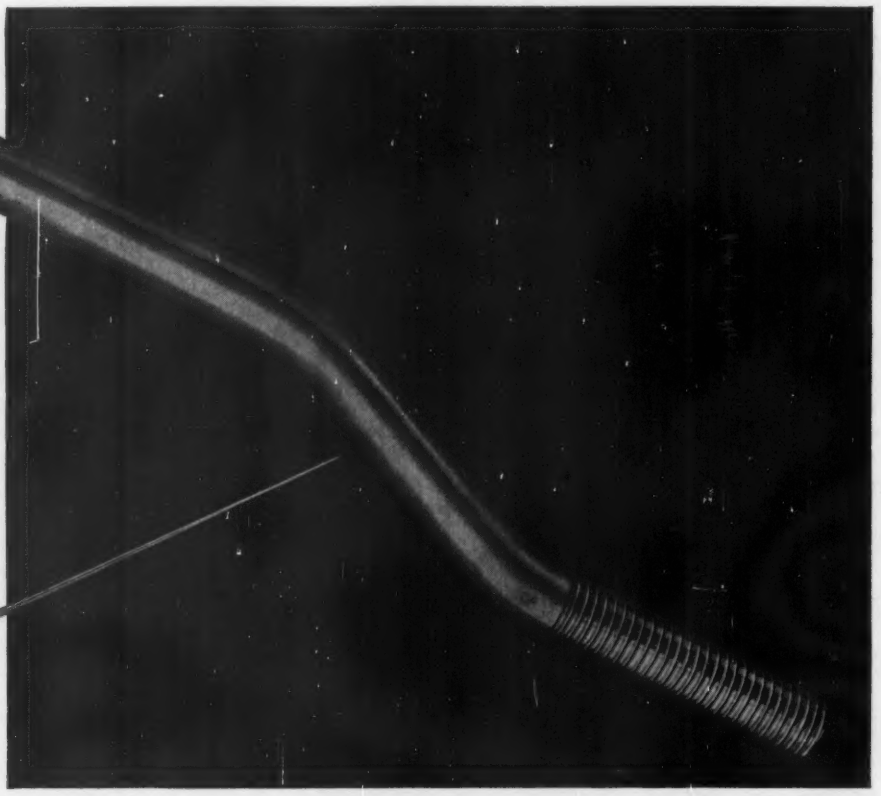
SAMPLES AND TECHNICAL DATA MAY BE OBTAINED FROM YOUR P-K INDUSTRIAL DISTRIBUTOR, OR WRITE DIRECTLY TO PARKER-KALON FOR BULLETIN NO. 862.

PARKER-KALON®
Socket Screws

PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey · Offices and warehouses in Chicago and Los Angeles.

Circle 443 on Page 19

NAT'S
quick facts
about
Fasteners...



Shining example...of big things in **specials** by National

This is a large offset eyebolt, shown here big as life. We designed and made it to order for one of our customers.

To begin with, it shows that we can and do make some sizable things in the way of cold headed Special Products.

But there's more here than seems to meet the eye.

When our customer brought us this eyebolt, he had been having it made as a forged eye welded to a machined bolt, with a cut thread.

We gave it some thought, then made it... with a difference. We cold formed it in one piece, and rolled the thread... turning out a stronger, more practical, and more efficient part, and lopping off costs all along the line.

And there's the real point... what we really mean when we mention doing BIG things in Specials, at National... better parts, large or small, at lower cost, by cold heading and designing for profit.

We do it right along, and we can very likely do it for you, too. Want to find out? Just drop a note to Special Products Service, at our address*. And if you just happen to have a Special problem, tell us all about it—and let us help.

*It will bring you this illustrated booklet "Bring your Special Problems to National", 16 pages about Specials as National sees them.

National PRODUCTS

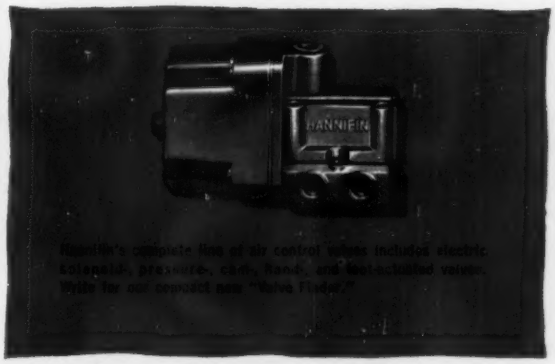
The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

Circle 444 on Page 19

For Literature on Hannifin Items Circle 445 on Page 19→
For Literature on Fittings and Hose Circle 446 on Page 19→

Hannifin air power cylinders, available in a full range of mounting styles, bore sizes from 1½" through 14", strokes to 20 feet. Cylinder bodies bored, then honed satin-smooth . . . for low friction, long packing life.



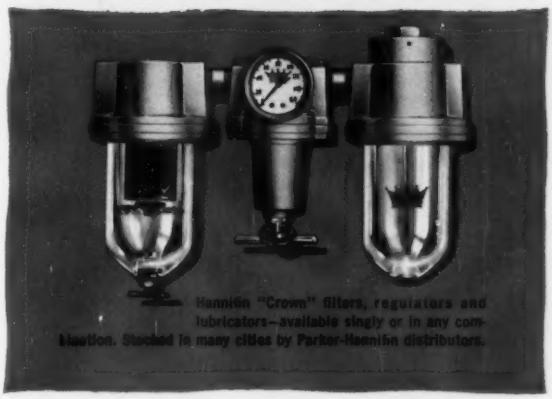
Hannifin's complete line of air control valves includes electric solenoid-, pressure-, cam-, hand-, and foot-actuated valves. Write for our booklet and "Valve Finder."

PARKER-HANNIFIN

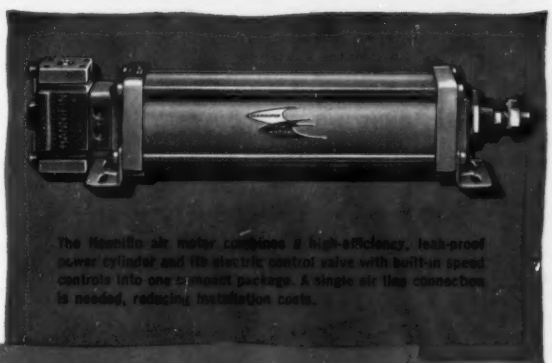
puts air to work without costly leaks

Now... complete pneumatic power systems, engineered for long leak-proof life, are available from your Parker-Hannifin man. Hannifin "Crown" units supply filtered, lubricated air at optimum pressure. Hannifin air valves shift quickly and seal bubble-tight. Hannifin air cylinders and air motors are low-friction, leak-proof. Parker "Push-lok" hose fittings and "Intru-lok" tube fittings provide quick, easy, leak-proof connections. The over-all result is more work from less air!

Our field engineering service helps you design your circuits and select the components. Many items are available locally, from Parker-Hannifin distributor stocks.



Hannifin "Crown" filters, regulators and lubricators—available singly or in any combination. Stocked in many cities by Parker-Hannifin distributors.



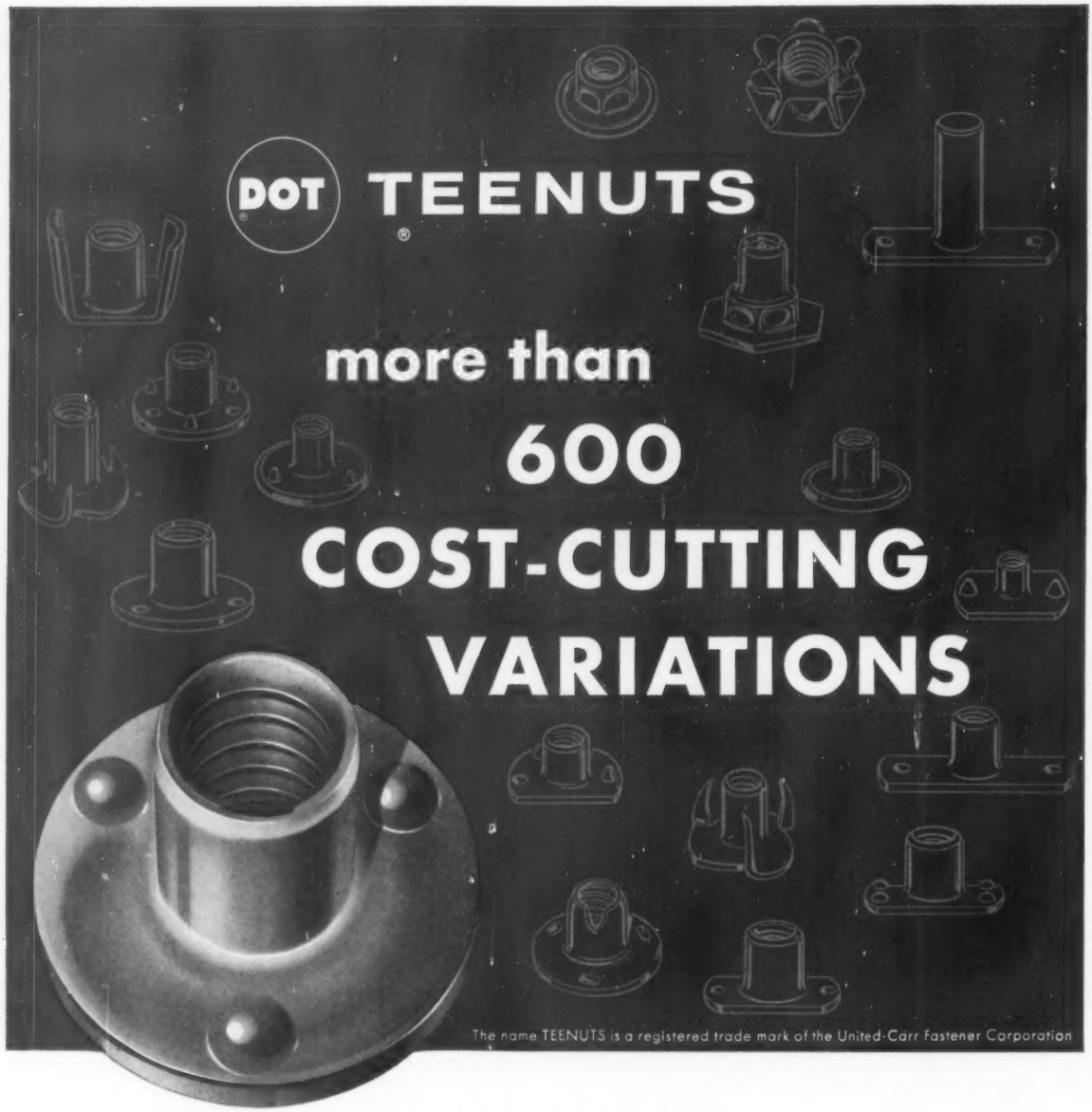
The Hannifin air motor combines a high-efficiency, leak-proof power cylinder and its electric control valve with built-in speed controls into one compact package. A single air line connection is needed, reducing installation costs.

A bench-backed hand push joins Parker "Push-lok" hose fittings to Parker hose. No tools required. Won't blow off.

Parker "Intru-lok"® tube fittings are for low and medium pressure lines in copper, aluminum, nylon or polyethylene. You simply insert the tube end and tighten the nut. No-leak, vibration-proof grip.

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

HANNIFIN COMPANY
555 S. Wolf Road, Des Plaines, Illinois



Since the first TEENUT was developed by Carr Fastener in 1927, more than 600 different modifications of this extremely versatile device have been designed and manufactured in true, mass-production quantities.

By combining nut and washer in one solid unit, the DOT TEENUT offers exceptional strength and security and eliminates the need for tapping. Its flanged base can be formed with welding bosses for attachment to sheet or solid metal structures . . . with prongs for wood . . . or with any number of different special bases for particular applications. DOT TEENUTS can be made in heat and corrosion-resistant materials and they can be provided with moisture-seals and vibration-proof, self-locking barrels.

Once mounted, the DOT TEENUT stays put and can't be lost or mislaid . . . an advantage at any time and a necessity where blind fastening is required.

Wide experience in the proper application of DOT TEENUTS and a multitude of other special-purpose fasteners enables your DOT field representative to provide prompt and effective solutions to a tremendous variety of fastening problems. Where special design work is needed, he can bring you the services of a design-engineering group unequalled in its field.

The DOT TEENUT catalog is an invaluable reference . . . yours on request.

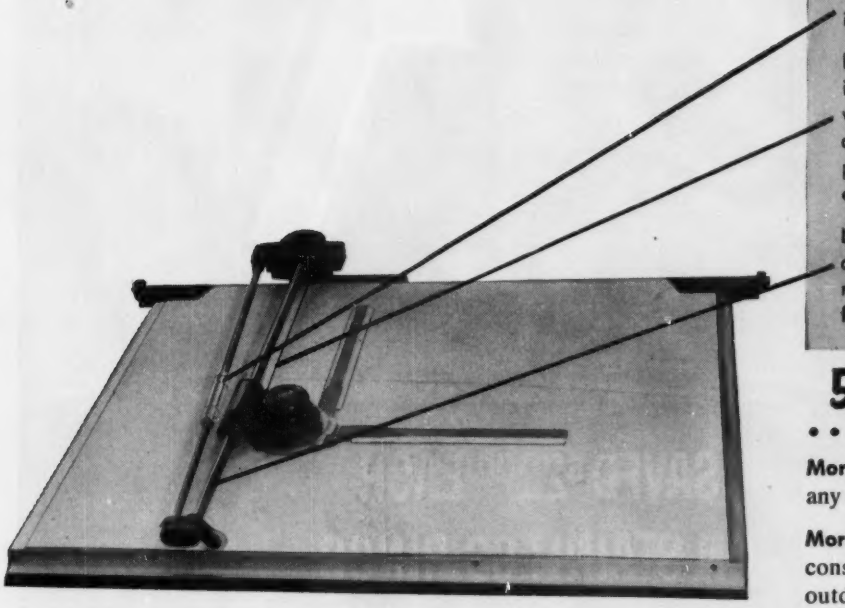
MAKERS OF DOT FASTENERS

CARR FASTENER COMPANY

Division of UNITED-CARR Fastener Corp., Cambridge 42, Mass.

Offices In:

Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Los Angeles, New York, Philadelphia, Syracuse



3 Ways Better

Horizontal positioning lock now centrally located to permit locking or releasing while seated.

Improved cable attachment and increased cable strength provide maximum protection against breakdown, cable-snapping, and the wear and tear of constant use.

Larger diameter vertical rail and attendant structural improvements afford increased rigidity for sharper, surer work.

5 Ways the Best

More Versatile – perfect balance at any board angle.

More Compact—advanced travel-rod construction completely eliminates outdated cumbersome counterbalances projecting over top of board.

More Adaptable – gives maximum sweep of *any* size board – even the largest wall models.

Better Made – as with every K&E product, precision engineering throughout . . . rigid construction means truer lines, more accurate work . . . glides smoothly on fine-ground stainless rails . . . all glide controls are readily adjustable for any touch, any board.

For Easier Use—scales move instantly at the lightest touch from one position to another . . . long lines can be drawn in a single motion, up, down or across . . . scales *lock* in place to eliminate drift . . . less tiring . . . smooth, feather-light action *actually reduces* number of arm and hand motions necessary to produce a finished drawing.

Even the Best Draftsmen are better with

The K&E Paragon®

Auto-Flow™

Drafting Machine

KEUFFEL & ESSER CO., Dept. MD-4, Hoboken, N. J.

☐ Please send information on the new K&E Paragon® Auto-Flow™ Drafting Machine.
☐ Please arrange a demonstration for me.

Name & Title_____

Company & Address_____

2044

Flash butt-welding an extruded section resulted in a 65% material reduction

By specifying an extrusion that allowed only a thin envelope of material around the finished cross-section, Amweld engineers saved 37 lbs. of 321 stainless—and eliminated considerable machining time. Amweld flash butt-welding know-how produced a ring that more than satisfied the critical strength requirements for this jet engine shroud.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

. . . MICROMETER SETTING

For Exacting Flow Control

HANNA *Flo-Set* VALVES

Hydraulic pressure to 1000 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

Air, Oil, water operation to 250 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

OTHER HANNA VALVES
include solenoid, pilot, hand and foot operated types

FOR AIR • OIL • WATER • OTHER FLUIDS

REGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves . . . you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are ¼", ⅜", ½", and ¾" . . . a ¼" Jr. model, without graduations or locking collar, is available for light piping and tubing.

Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

WRITE FOR LITERATURE AND COMPLETE DETAILS,
or consult your classified telephone directory or Thomas' Register for your nearest Hanna representative.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue • Chicago 22, Illinois

HERCULES Plastics Hi-Lites

Vol. II, No. 1

New plastics are the big story in today's modern appliances

INSIDE OR OUT, PRO-FAX® APPLIES—a real performer, Pro-fax! It's built to stand up to the most rugged use challenges whether they be indoors or outside. As a result, this newest of plastics—Hercules polypropylene—has been finding increasing use in appliances that call for the finest in appearance and performance. Tough, rigid, heat-resistant, hard to stain, Pro-fax is richly colorful and the lightest plastic ever.

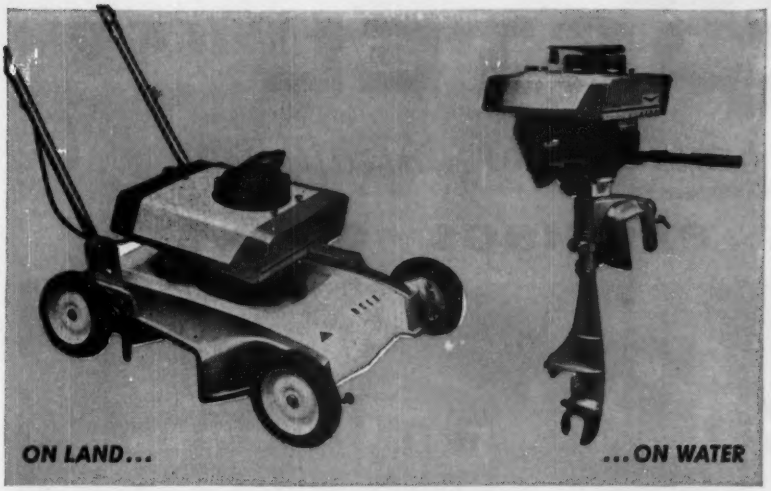
Pro-fax has opened up a whole area of new thermoplastic usage. Now designers have at their command a structural material that can often be used to replace more costly raw materials. Easy to mold, Pro-fax can be used to produce precision-formed units at low cost. It's little wonder that so many of the nation's leading appliance manufacturers are turning to Pro-fax to help solve production problems, and to give added values to their products.

A TRIPLE PLAY BY PRO-FAX

This Triple Duty Filter Dispenser, an exclusive feature found in all Philco-Bendix "Automagic" washers, is another example of the advanced engineering made possible by the proper use of such new plastics as Pro-fax polypropylene. Exploded view (left) shows the six injection-molded parts which make up the assembly of this compact, highly functional unit. Removable cap and cup shown at top are polyethylene. The remainder of the unit consists of four precision-molded Pro-fax parts which are ingeniously joined to form the body of the dispenser filter. The dispenser lid is permanently joined to the upper half of the body by spin-welding, while the lower half is attached by self-tapping screws. The removable filter trap (at bottom) has a molded bayonet-type catch, with an insert-molded metal mesh filter. Pro-fax was selected for this demanding assignment because of its outstanding resistance to detergents and chemicals, and its ability to withstand prolonged exposures to high temperatures. Lightweight; a handsome, colorful finish; and resistance to breakage are other features of the new unit. And of course the producer enjoyed all the important processing bonuses provided by Pro-fax, including more parts per pound, and dimensionally stable, precision fitting components.

Instantly accessible when the washer is open, Philco's Triple Duty Dispenser serves three important functions in the washing cycle. The entire tub of water is filtered six times a minute to remove all traces of lint. It provides automatic detergent dispensing at any preselected water level, insuring even dispersion; and it automatically dispenses clothes conditioner at the proper time to assure a softer, cleaner wash.

Molded by Seneca Plastics Company, Cambridge, Ohio.



DOUBLE PLAY BY ACCO

The new Acco "Outboard Mower" is not only an industry first, but one of the first big new merchandising ideas of many a year. It's a power mower with a motor that can be removed and attached to a propeller unit to make a powerful outboard motor. The conversion can be effected in minutes, and on land or water the motor is protected at all times by a colorful, durable housing molded with Pro-fax. Pro-fax proved the only plastic with all the requirements demanded by this new concept in dual-purpose equipment: lightweight, rigidity, resistance to heat, chemicals and staining, plus a lustrous surface finish that bespeaks quality merchandise.

Molded by Research Plastics, Inc., Jersey Shore, Penna.

A HIT BY REGINA

This attractive, low-cost plastic accessory is certain to be a hit with homemakers who own a Regina Polisher-Scrubber. Waxing is no longer a chore with this new automatic dispenser unit. Fingertip control assures uniform distribution of wax, avoiding waste and yielding professional results without splashing or stooping. For the ultimate in appearance and performance in this new appliance accessory, Regina selected Pro-fax. In addition to providing lightweight strength in a handsomely styled unit with a colorful, stain-proof finish, Pro-fax supplies the excellent sealing qualities needed for a leak-proof seal, plus resistance to wax solvents such as turpentine.

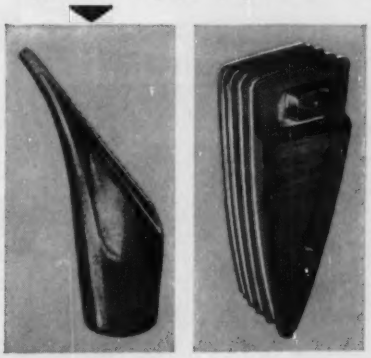
The new Pro-fax pump unit is easily attached to the Regina Polisher-Scrubber handle. When not in use, it will not hamper normal operation.

Pump unit molded by Ideal Plastics Division, Ideal Toy Corporation, Long Island, New York.

Design Hi-lites

The dramatic change-over by producers of light-duty liquid detergents to blow-molded plastic bottles has focused new attention on a long-established processing technique. Blow-molding is one of the oldest of plastic arts, and designers have long been intrigued by the intricate shapes and unusual forms which can be achieved by this method. Until recently, however, materials adaptable to blow-molding lacked the structural and functional characteristics required to yield rigid structures suited to a wide range of uses. The advent of such new plastic materials as Hi-fax, high-density polyethylene, has changed this picture to the point where blow-molding has now become the fastest growing sector of our industry.

Permitting the use of undercuts, blow-molding can achieve intricate shapes impossible by other methods. Modern version of classic vase in design below could serve as watering can, condiment bottle, or medicinal container. Sketches by Sundberg-Ferar.



Blow-molded Hi-fax containers can be designed with a "bellows" action in packages that serve as pumps or dispensers. Design shown above is for a household deodorant or insect spray container.

The sketches shown here are but two of the many exciting and different product ideas shown in a new Hercules film-strip, "Something New in Packaging." If you'd like to see this up-to-date report on a new industry and the materials which serve it, write or call us. It will take only minutes of your time, may put your new products years ahead.

CP60-3

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

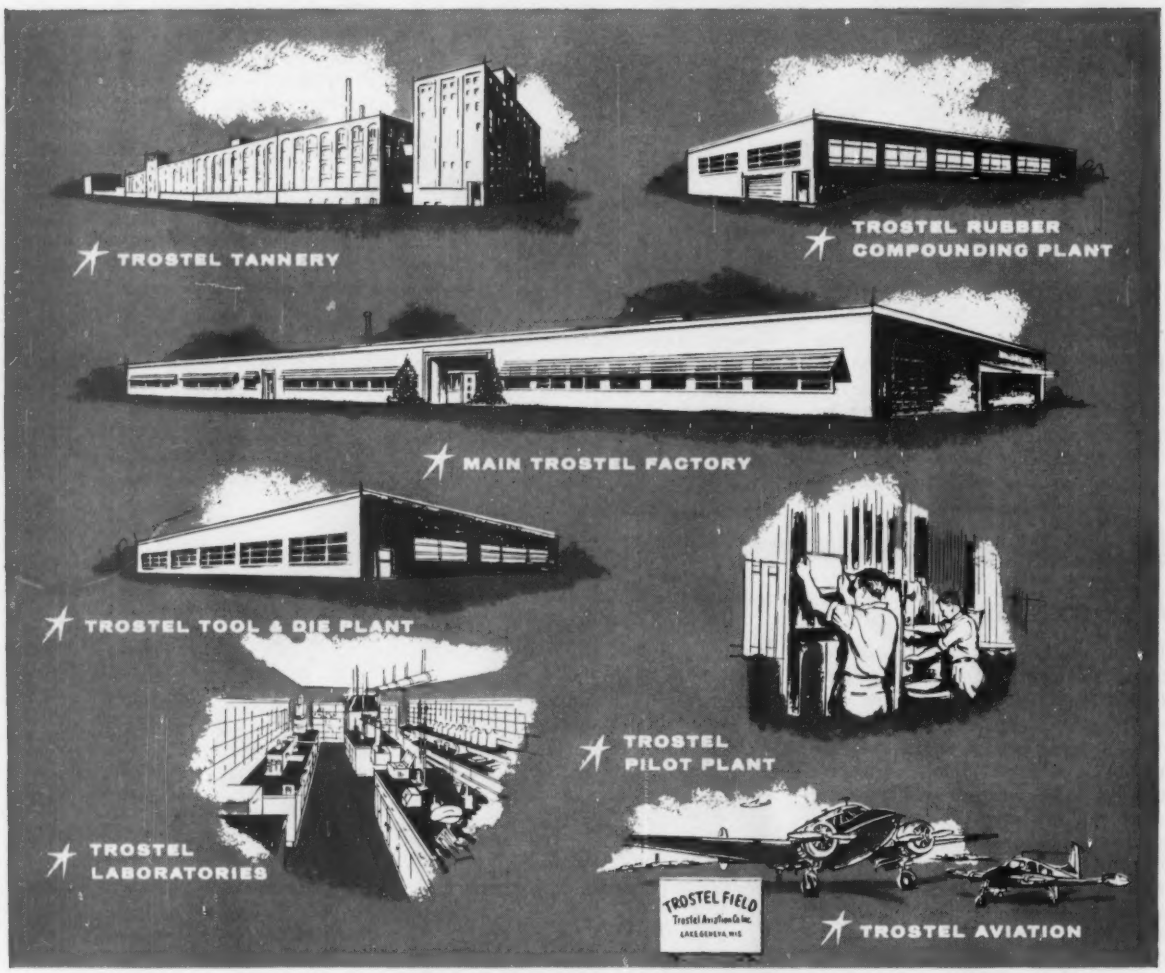
HERCULES

Circle 451 on Page 19

TROSTEL

A complete producing organization for

☆OIL SEALS ☆PACKINGS ☆O-RINGS



Quality in every phase of supply and manufacture is assured through Trostel ownership of all essential facilities

From raw materials to finished product, all key sources of supply and manufacture are Trostel owned and operated. Leather is tanned at the Trostel Tannery. Rubber is compounded at the Trostel Compounding Plant. Dies are made at the Trostel Tool and Die Works. Three separate Trostel Laboratories conduct research in leather, impregnations, and synthetics. A pilot plant tests all production runs. When, therefore, parts and materials arrive at the point of manufacture into seals and packings they are uniformly standard in specifications. Manufacture itself is by automatic machinery in a modern plant, with a quality control system that insures close-tolerance accuracy in all operations. Special delivery and service are provided by Trostel Aviation . . . we can come to you quickly, or bring you to us.

Trostel control of its products from raw materials to delivery is your guarantee of dependably high quality at all times, on every order. For catalog and technical data, write Albert Trostel Packings, Ltd., 600 Madison St., Lake Geneva, Wis.

TROSTEL
QUALITY
SINCE 1838

PACKINGS
OIL-SEALS
O-RINGS

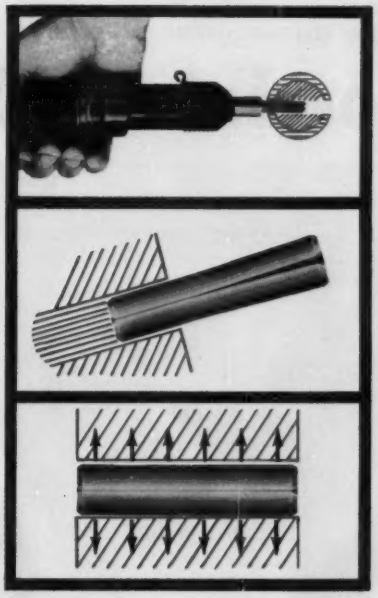
Circle 452 on Page 19

Rollpin won't mushroom or telescope

There are no installation or removal problems with Rollpins. Because of their column strength they can be readily driven with a hammer, removed with a punch without bending or collapsing. Of course production line tooling such as an arbor press, a pneumatic hammer . . . even a hand riveter . . . is ideal for Rollpin insertion.

Rollpin won't damage or enlarge hole

With smoothly chamfered ends providing an easy lead-in, Rollpin is compressed into complete conformity with the shape of the hole. The exclusive, v-shaped, coped corner design eliminates possibility of damage to the hole walls. They prevent any possible scoring action as the pin is driven and insures uniform insertion and removal characteristics. The benefit to you: the same pin can be reused in the same hole.



ONLY ROLLPIN OVERCOMES ALL THESE FASTENING PROBLEMS!

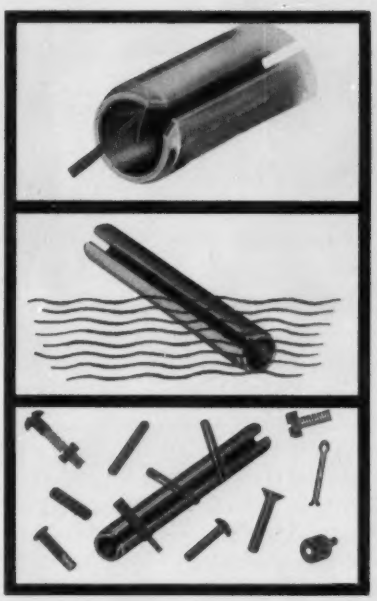
Rollpin exerts EVEN pressure

In some fasteners, only a portion of the fastener shaft does the actual holding. Rollpin, however, exerts a uniform pressure around the entire inside surface of the hole—giving you maximum holding power and superior resistance to vibration.

Split tubular construction assures uniformity of heat treatment that is difficult to obtain with spiral types of pins; there is an even plating "throw" inside the pin as well as outside – for superior corrosion protection; there are no thin edges susceptible to damage.

ONE TYPE of Rollpin does EVERY TYPE of job

Versatile Rollpins will replace at least 12 different types of fasteners. Every Rollpin can be hopper-fed, can be installed with a single operation. They are available, from stock, in a wide range of lengths and in diameters from 1/16" to 1/2". Manufactured from carbon or corrosion resistant steels and beryllium copper.



ROLLPIN®

ELASTIC STOP NUT CORPORATION OF AMERICA

WHERE CAN YOU USE THIS VERSATILE FASTENER? MAIL COUPON FOR SAMPLES:

Dept. R59-44, Elastic Stop Nut Corporation of America

☐ Please send me ROLLPIN samples

☐ Please send me ROLLPIN bulletin

Name_____

Title_____

Firm_____

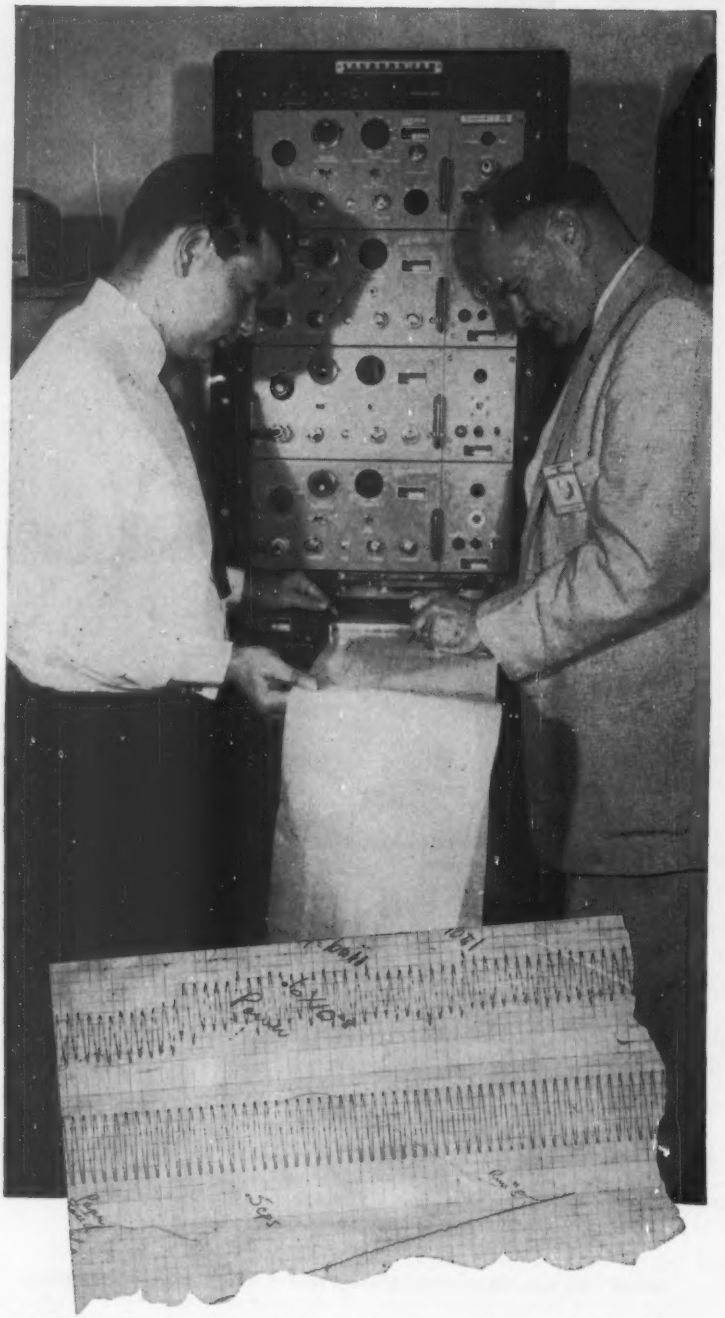
Street_____

City_____ Zone____ State_____

Circle 453 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



"Heatrace" heat-sensitive chart paper manufactured by Nashua Corporation, Nashua, N.H., using Hycar nitrile latex is being used for medical and industrial applications—including all Minitrack installations around the world. B.F.Goodrich Chemical Company supplies the Hycar nitrile latex.*

**Trade Mark*

Hycar helps new chart paper make a faster, better record

This new heat-sensitive chart paper improves the accuracy of line and legibility of tracings because it is more sensitive to a heated stylus. It is made with a base coating of Hycar nitrile latex.

Originally designed to improve the resolution of electrocardiograms, the new paper is also proving ideal for high-speed space instrumentation. The base coating of Hycar provides a water-proof structure that prevents graying of the surface coating under high humidity conditions. This smooth, flexible coating also adds to the paper's durability, making it particularly useful where extensive handling is required.

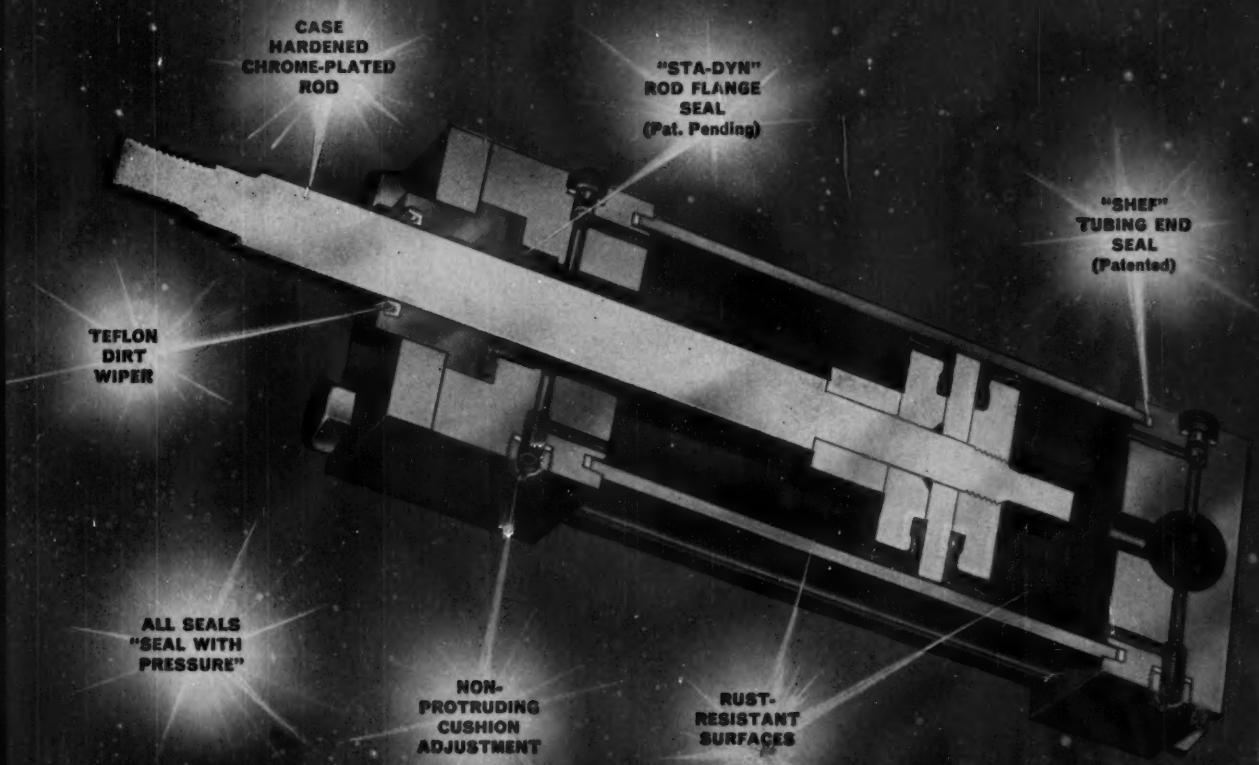
In latex forms like this, and in many other forms, Hycar nitrile rubber is adding advantages to products—or opening whole new markets. For more information, write Dept. FO-2, B.F.Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
REG. U.S. PAT. OFF.
Rubber and Latex

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

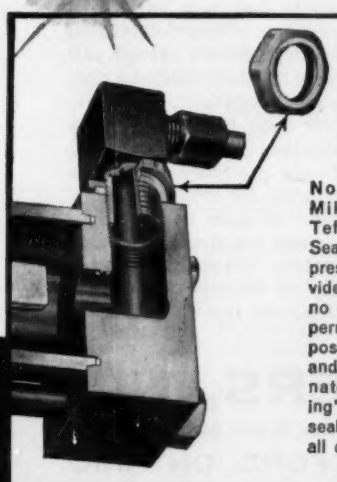
B.F.Goodrich GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"STA-DYN" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS

PORT SEALS



Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

Specify "Miller" for greater reliability and economy! Write for bulletin.

See Our Educational Exhibit, ASTE Show, Booth #1331

MILLER FLUID POWER

7N016 YORK ROAD, BENSENVILLE, ILLINOIS

Motors Thrive on FREQUENT OVERLOAD ABUSE!

***Brunswick* D-31 Precision Bowling Lane Sanders**

Powered by Lightweight R&M 8 HP Single Phase Motors

The Brunswick-Balke-Collender Company recently handed ROBBINS & MYERS an unusual motor problem when it re-powered the Brunswick D-31 precision bowling lane sander. The D-31 cuts across 250 square inches of area in one continuous cutting operation. Motor must withstand frequent and severe overloads when the machine levels high spots in the alley bed. Power had to be single-phase, too, because many bowling establishments carry only single phase current! To keep sander truly portable and easily maneuverable . . . and to protect lanes from excess weight, motor had to be lighter than ordinary single-phase motors.

ROBBINS & MYERS custom-designed an 8 HP capacitor-start, capacitor-run motor that is daily proving its stamina against these rugged requirements. Should more power be needed, design includes provision for adding an auxiliary blower which can conveniently increase capacity to 10 HP. Weight was kept down by using special aluminum end heads. For easier maintenance, the extended end-head housing can be removed quickly and easily to expose condensers and centrifugal switch.

Many other features insure longer life for *every* R&M motor: double width bearings that have extra-large grease capacity . . . Mylar* insulation with 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling.

For motors to meet unusual challenges . . . and for standard motors, always contact ROBBINS & MYERS! Write today for Bulletin 470-MD

**DuPont registered trademark*

ROBBINS & MYERS, INC.

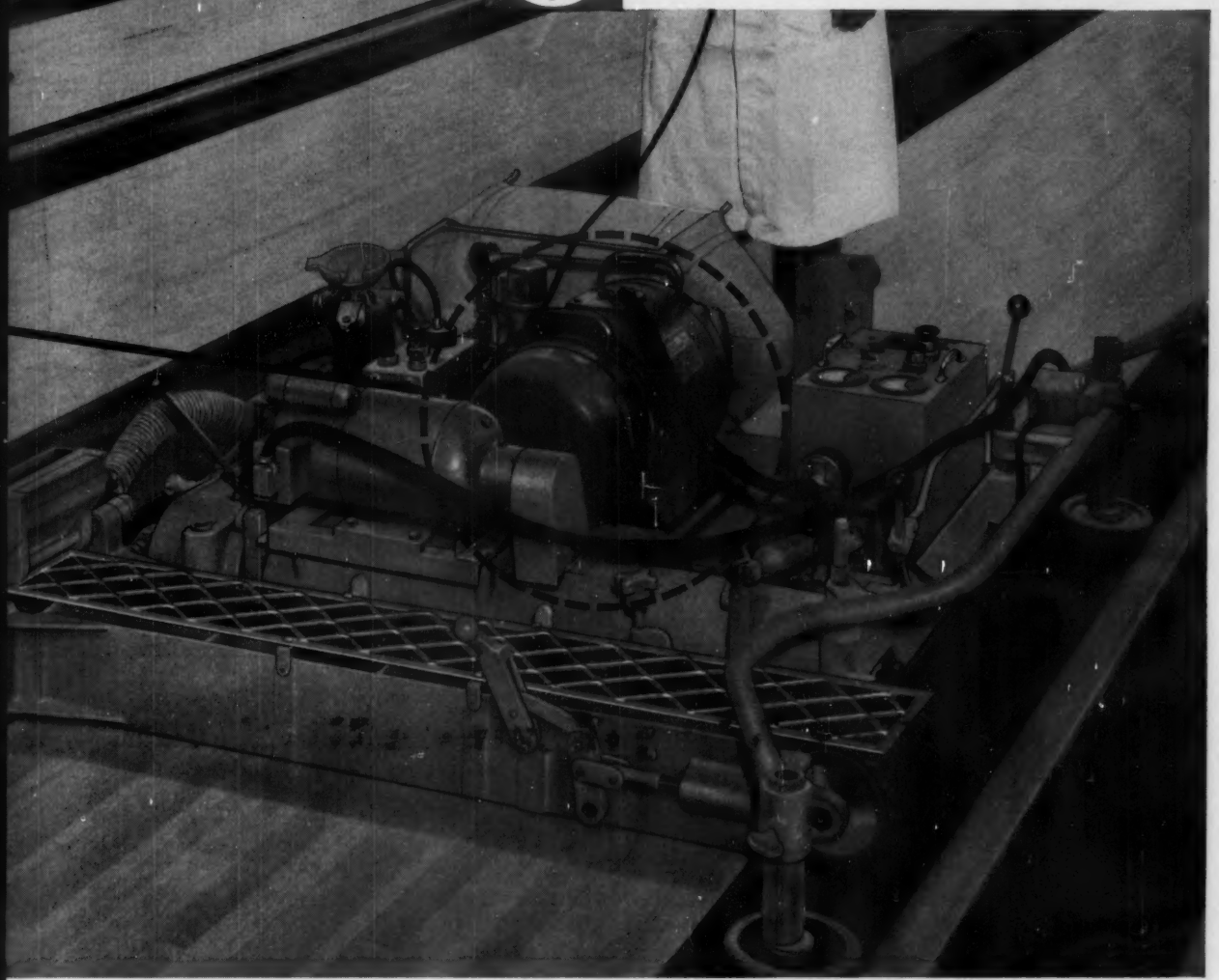
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

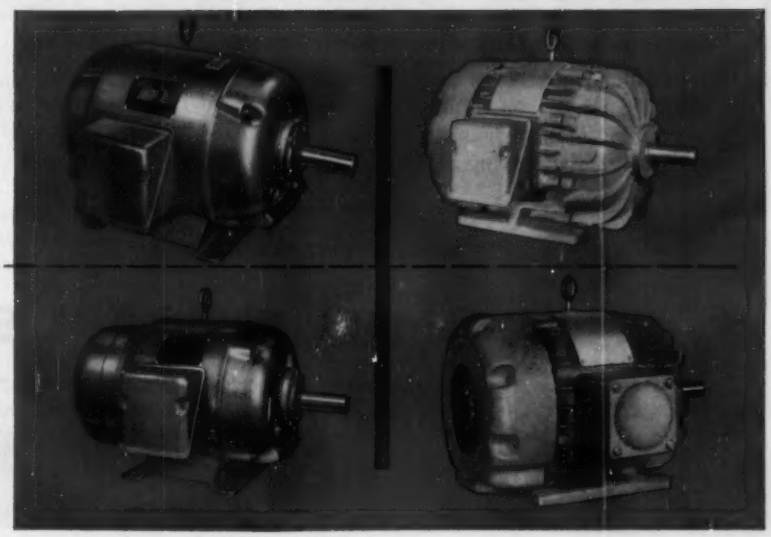
SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

Circle 456 on Page 19

MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)





Open Protected Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.

How are they doing down on the farm?

Nowadays they're doing everything a lot easier, thanks to modern power-operated farm machinery.

And farm machinery producers have learned that their lot can be a lot easier, too, when they specify Ostuco Tubing. That's because there's no compromising with custom-quality Ostuco Tubing. Consistently you receive the exact tubing you want — the size, length, grade — with the strength and tolerances you need. For machined parts, you get our recommended rough size guaranteed to clean up.

In addition to these advantages, Ohio Seamless will fabricate tubular parts to your specification. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.

A-1308A

Complimentary Copy of new Bulletin CS60 "Ostuco Steel Tubing" sent on request.

Model illustrated built to 3.5 mm scale.

OSTUCO SHELBY, OHIO

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Division of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

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CANADA: Ridgeway & Power Equip. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

Veeder-Root READOUT Bulletin

One of a Series

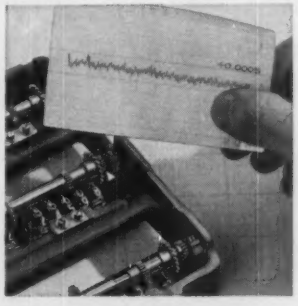
New "White Room" Assembly Insures Accuracy, Reliability of Instrument Counters

This special facility has been designed to provide positive environmental control for ultra-precision assembly and test of Veeder-Root Instrument Counters. Temperature and humidity are constant and electrostatic filtering and pressurization maintain air purity.

This is the latest step taken by Veeder-Root to insure top reliability and accuracy in counters and readout devices used for instrumentation, aircraft and navigational applications. Veeder-Root offers an extremely varied line of these instrument type counters; and also does extensive design and prototype work to develop new devices for all types of readout problems. Whatever your needs for precision counting devices, Veeder-Root can provide that extra margin of dependability by supplying a single counter or complete counting package or system. Your specifications will receive prompt attention.

Veeder-Root Precision Gearing Provides Long Life, Accuracy at High Speeds

The secret of Veeder-Root precision counter performance is the close tolerance manufacturing and inspection of gearing, typified by the strip chart record shown here. This Veeder-Root experience with all types of intricate gearing, to Precision Class 2 tolerances, assures accuracy and dependability in readout devices and counting packages.



Send for More Information . . . or advise your precision counter requirements. Application assistance is available from Veeder-Root Counting Engineers or write.

Veeder-Root

HARTFORD 2, CONNECTICUT

"The Name that Counts"

New York • Chicago • Los Angeles • San Francisco • Seattle
St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal
Offices and Agents in other principal cities

This is a Veeder-Root Counting Package developed for airborne navigational systems. It is being assembled and tested in the new "white room".

Series 1597 Miniaturized Counter

designed for readout of navigational data. Features maximum figure size on ½" wheel, plus small overall dimensions and light weight. For high speed counting.

Series 1698 Internal Pinion Counter

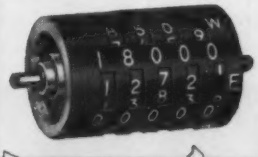
developed for aircraft instrumentation such as altimeters, fuel readout and manifold pressure. Wheels are only 0.672" in diameter.

Series 1392 Open Frame Counters

for navigational computers. Has extremely low torque, wheels are ball-bearing mounted, and counter is available with various frame styles for mounting into "packaged" systems.

Series 1666 Precision Internal Pinion Counter

available with 3 or 4 figure wheels, in single or tandem styles. Minimum size, maximum readability.



Series 1387 and 1388 Concentric Drum Counter

for latitude and longitude readout. These counters offer compact digital presentation, speeds to 300 rpm, and unusually long counting life.

V10-3

Veeder-Root, HARTFORD 2, CONNECTICUT

☐ Please send Precision Counter Data Sheets
☐ Please have Counting Engineer call

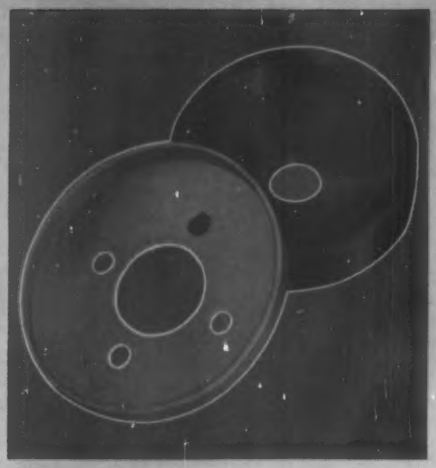
Name.....

Title.....

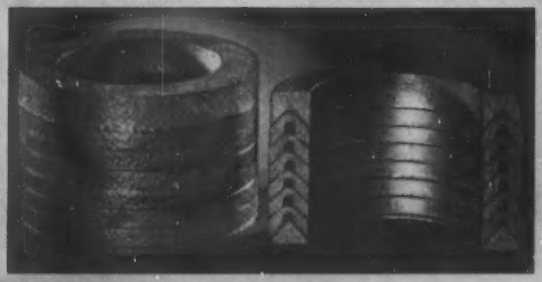
Company.....

Address.....

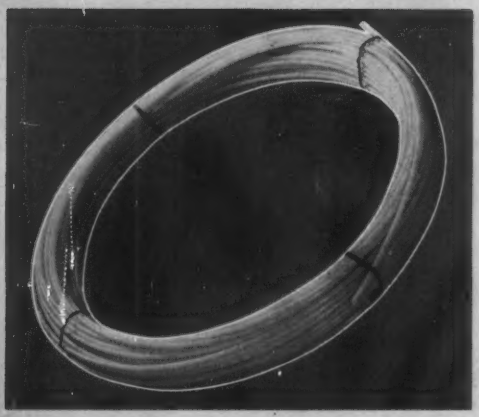
City..... *State*.....



LEATHER CUPS are naturally tougher than other materials . . . suitable for most applications. Fabric cups are recommended for severe service.



CHEVRON PACKINGS permit free operation with minimum friction at all pressures . . . last longer, need less maintenance.



CHEMISEAL NYLON PRESSURE TUBING is unaffected by solutions which corrode metal . . . costs less than metal . . . available from ⅛" O.D. up.

ENGINEERED PRODUCTS

for
Hydraulic-Pneumatic
Service

TOP EFFICIENCY WHERE FLUID POWER IS INVOLVED

Garlock Leather Cups actually tend to polish metal surfaces they contact. Provide good resistance to abrasion and wear . . . unmatched for tensile strength and toughness . . . low coefficient of friction, minimum cold flow. All sizes, shapes, designs available for wide variety of pressures, temperatures, non-caustic fluids. For more severe service conditions, rubber fabric-inserted cups are generally recommended. Catalog AD-145.

Garlock CHEVRON* Packings are as close to "frictionless" as you'll find. As pressures increase, the packing rings tighten to prevent leakage; with declining pressures, the rings ease off, permitting free operation of the rod, ram, or piston without leakage. Once installed, need no further adjustment to meet pressure variations. Available in many materials, including Teflon† for practically all applications. Catalog AD-115.

CHEMISEAL* Nylon Pressure Tubing by Garlock is the ideal answer for hydraulic and pneumatic lubrication, oil, and fuel lines and vacuum system connections. It resists fatigue, abrasion, impact . . . withstands temperatures from −60° F to +180° F and higher. 1000 and 2500 psi grades available, conforming to J.I.C. specs. You can flex it or bend it for greater design freedom, versatility. Catalog AD-171.

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Take advantage of this "know-how" in the design field. Talk to your local Garlock representative at the nearest of our 26 sales offices and warehouses throughout the U.S. and Canada. Or, write The Garlock Packing Company, Palmyra, N.Y.

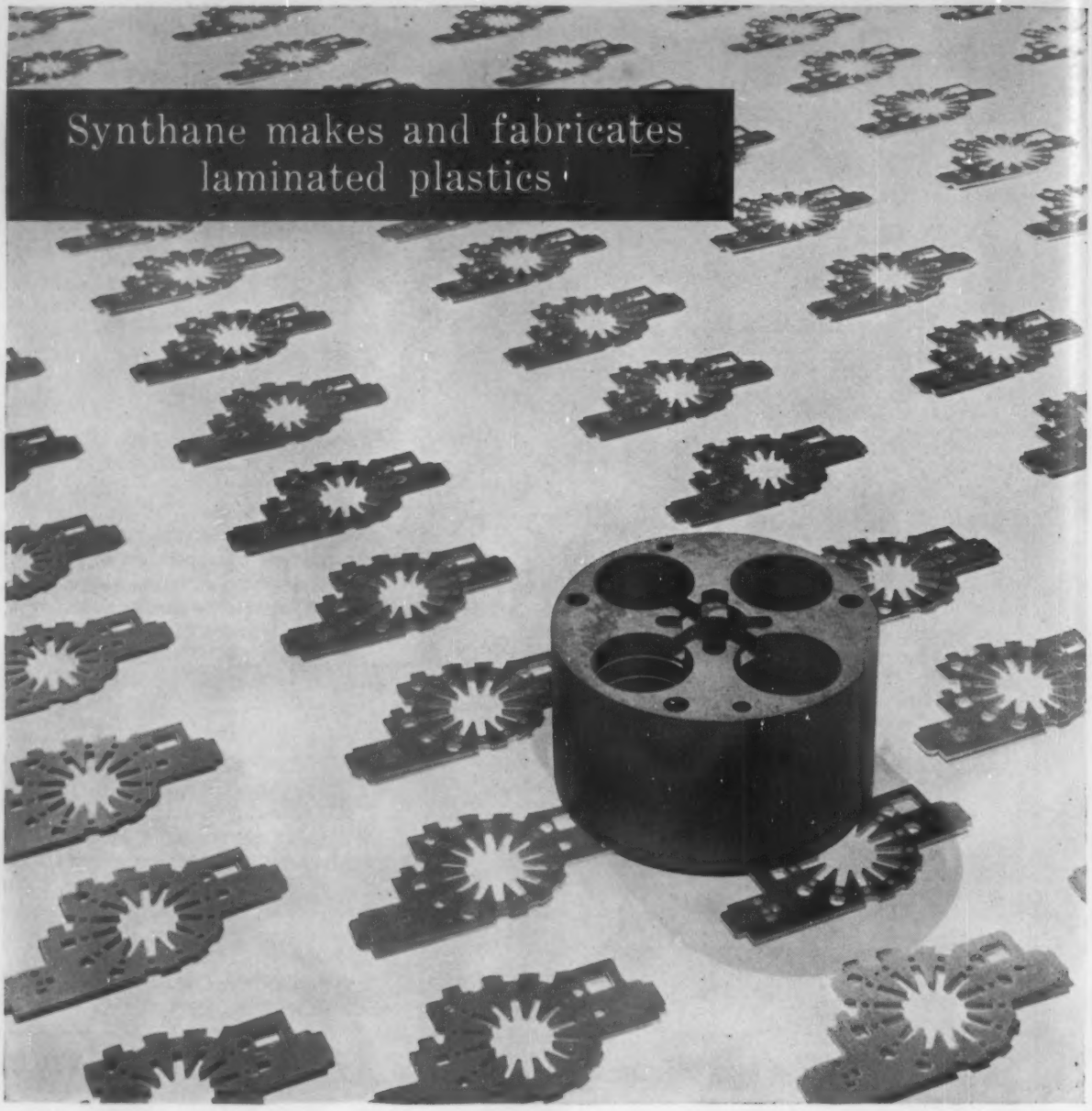
Canadian Div.: The Garlock Packing Company of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

*Registered Trademark
†DuPont Trademark

Circle 459 on Page 19



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Circle 460 on Page 19

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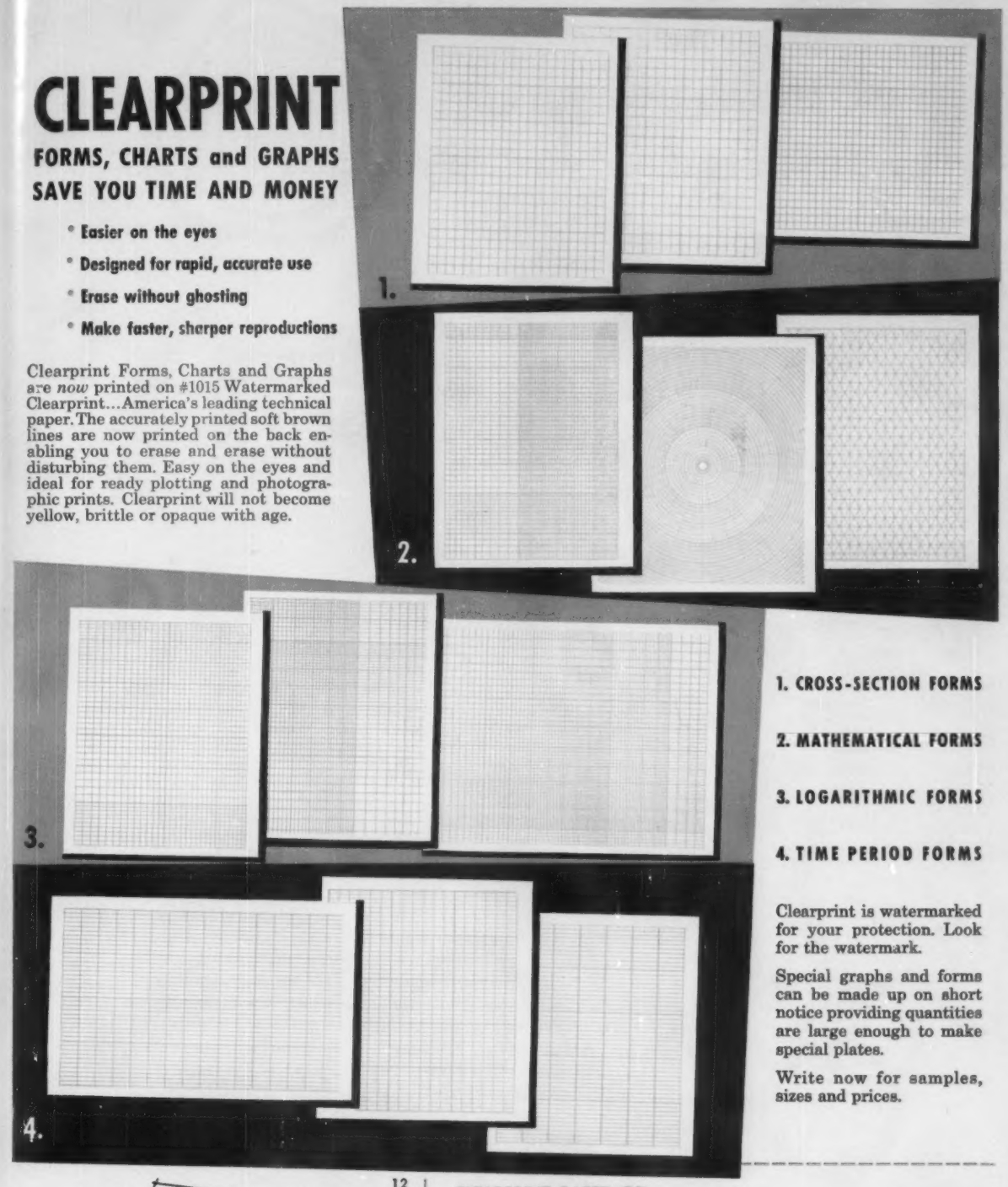

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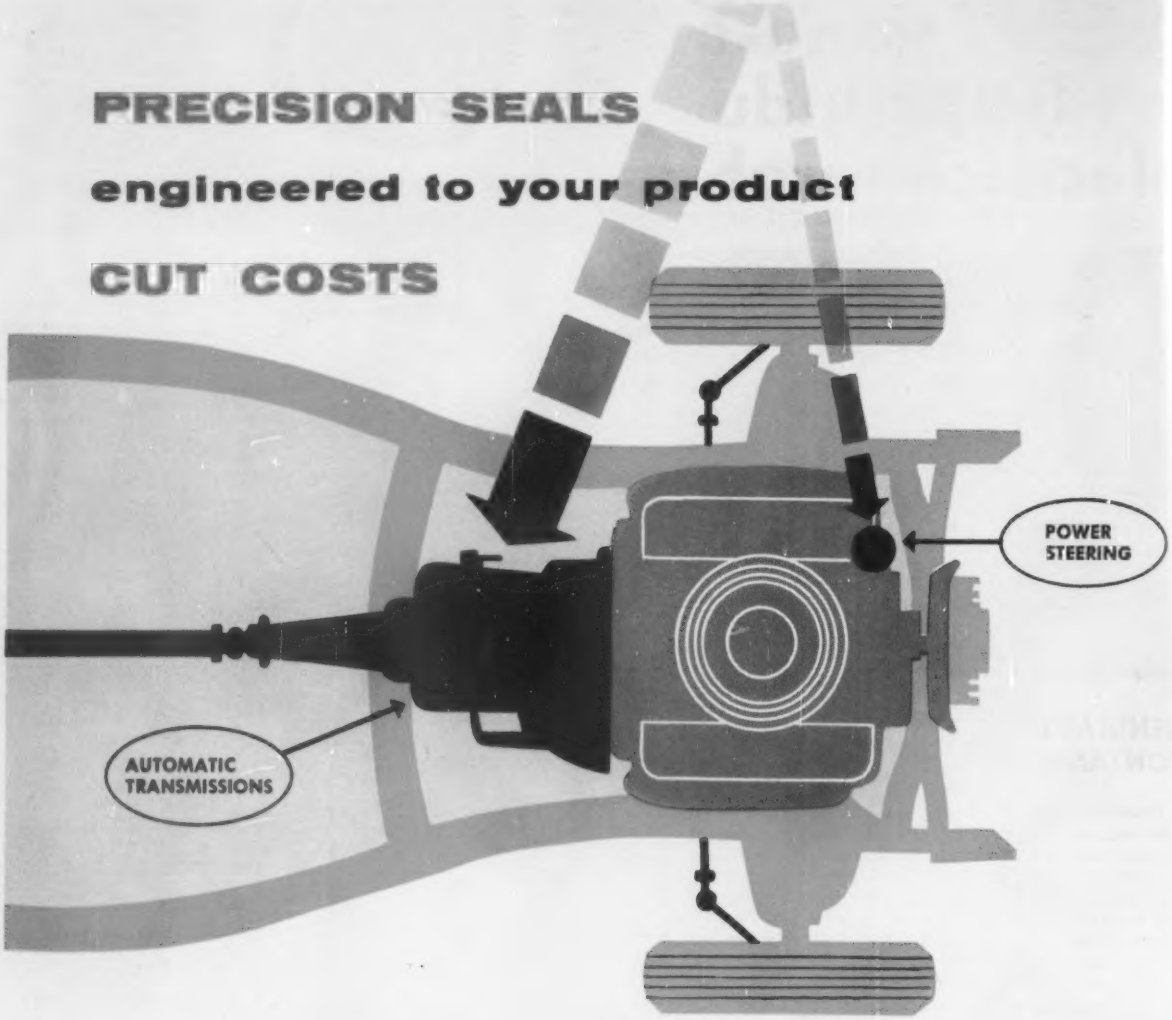


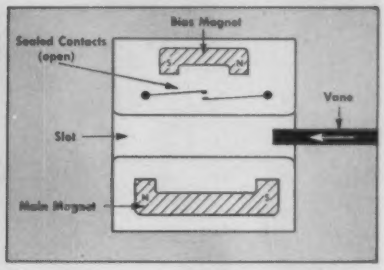
Problem Solving is a common occurrence at Precision. One was the development of a universal compound for automatic transmissions and power steering systems. **The Solution**—Precision Compound No. 6767—provided an "O" Ring with these characteristics. Suitable for all transmission fluids . . . particularly type "A" . . . long life over a temperature range of —40F to 300F . . . excellent resistance to cracking . . . low volume change . . . low compression set . . . high modulus. Precision creative research has reduced costs by producing the right "O" Ring for many manufacturers. You can benefit too, for the services of a Precision engineer are available to help you obtain the right product design and the right "O" Ring for it. Write or phone for his services today.

Precision Rubber Products Corporation

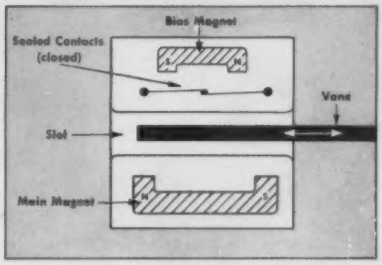
"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Thérèse de Blainville, Québec**

NEW vane-operated limit switch helps industry solve major electrical problem: limit switch life



On normally open form, bias and main magnet flux are balanced at the switch, causing it to remain open. As vane enters the slot, flux of the main magnet is shunted to the lower reluctance path offered by the magnetic material in the vane.



As vane passes the center of the switch, enough flux shunts from the main magnet to cause the flux of the bias magnet to close the switch. Withdrawing vane from the slot reverses the conditions and causes the switch to reopen.

GENERAL ELECTRIC'S ENCAPSULATED DESIGN SEALS OUT CONTAMINANTS; HAS NO ARMS, LEVERS, OR SHAFTS

General Electric's new vane-operated limit switch design surmounts most of the operating problems that cause failure in today's conventional limit switches. The unique new limit switch performs the position-detection function of conventional switches and *eliminates physical contact with the moving object.* It has no shafts or arms to fail, no sliding or rotating parts to wear, no shaft seals to leak.

This means that the operating life of the vane-operated limit switch is not affected by such tough application requirements as frequent operation; hammering of lever arms and mechanisms; lever arm "snapback"; mechanical wear; and splashing and spraying of coolants, lubricants, and other contaminants.

REASONS FOR LONGER LIFE

Contributing to the extremely long life of the new device is the encapsulation of all internal components in a cast aluminum enclosure. This means liquids, dirt, or metal chips cannot enter the switch mechanism and cause operational failure.

In addition, the only moving parts in the new design are magnetic reed contacts hermetically sealed in an inert gas. Thus, switch life is determined almost solely by contact load. When used with small a-c relays, such as the G-E CR2790 general purpose type, the expected operating life of the switch is from 30 to 50 million operations. It is capable of over 250 million operations when operating General Electric static control circuits.

The inherently longer life of the new vane-operated limit switch results in savings from greatly reduced maintenance and replacement expense and less downtime. And the new switch costs about two-thirds less than proximity switches, making it only slightly higher in price than a conventional limit switch.

HOW IT WORKS

The vane-operated limit switch is energized by passage of a separate steel vane through a recessed slot in the switch (see illustrations at right). The vane is attached to the mechanism to be controlled. As the vane passes through the slot, it changes the balance of the magnetic field, causing the contacts to operate. The contacts are hermetically sealed in an inert gas to prolong life.

The new switch is easy to install. Front- or top-operated forms are available to control linear or rotary travel. In addition, the base plate can be rotated 90° to provide mounting flexibility. Both normally open and normally closed forms are available with or without an indicating light. The new limit switch is 25 percent smaller than previous models, and it requires no separate power supply or amplifier.

The switch can detect very high speeds of vane travel without detrimental effects such as arm or mechanism wear or breakage. The switch also offers excellent accuracy and response time. Providing the path of the vane through the slot is constant, trip point repeatability is constant within plus or minus 0.0025 inch. The switch response time is approximately one millisecond.

MEASURABLE ADVANTAGES

Vane-operated limit switches hold significant and measurable operating advantages over conventional limit switches. These advantages can be measured by the maintenance and replacement savings they can produce, and deserve serious consideration on limit switch applications.

For more information contact your G-E sales office or request bulletin GEA-6995 from General Electric Company, Schenectady, N. Y. 811-8

GENERAL ELECTRIC

You get
MEASURABLE ADVANTAGES
with General Electric control.

Circle 463 on Page 19

DAYTON POLY-V® Drives provide new approach for project development at Borg-Warner

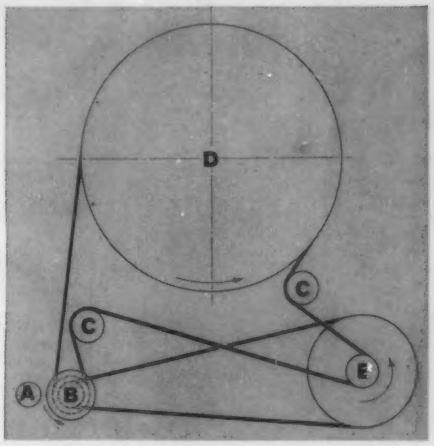
3 stage drive trimmed to 2 stages on combination washer-dryer

The Spring Division of Borg-Warner Corp. had developed a highly efficient drive for washer-dryer combinations using two of their patented clutches. However, large speed reductions were required which meant that a conventional three-stage reduction drive was necessary if V-Belts were used.

Dayton's Drive Engineering Service recommended that they try the Dayton Poly-V Belt, which uses smaller sheaves and shorter center distances, and provides greater gripping power in addition to noise and vibration freedom. To achieve maximum wrap on small sheaves, idlers were to be used which subjected the belts to an extreme reverse bend. Since the Poly-V Belt construction embodies a very thin cross section it lends itself to extreme reverse bending and long flex life.

Following Dayton's suggestion Borg-Warner engineers were able to design a compact, highly efficient drive of *only two stages* . . . using the outstanding Dayton Poly-V Belt.

Let Dayton's special Drive Engineering Service help you with your power transmission problems. Whether your design is still on the drawing board or in production write or call us for Dayton's Drive Engineering Service.



A—Solenoid: operates clutch. B—Unisprag *controllable clutch. C—Idlers. E—Tri-Cyl* one-way clutch.

Skillfully designed drive for automatic washer-dryer allows constant speed motor to deliver either spin or tumble speed at the flick of a solenoid . . . *with only 2 Poly-V Belts.*

*Reg. tradename, B/W Corp.

INDUSTRIAL DEPT

Dayton Industrial Products Co.

2001 Janice Avenue Melrose Park, Illinois *A Division of The Dayton Rubber Co.*

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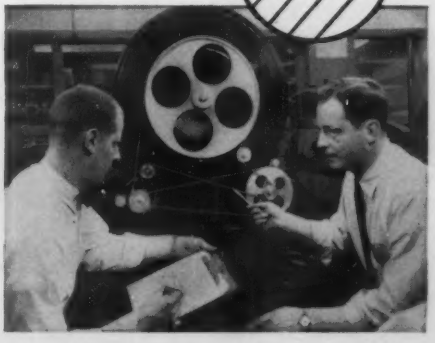
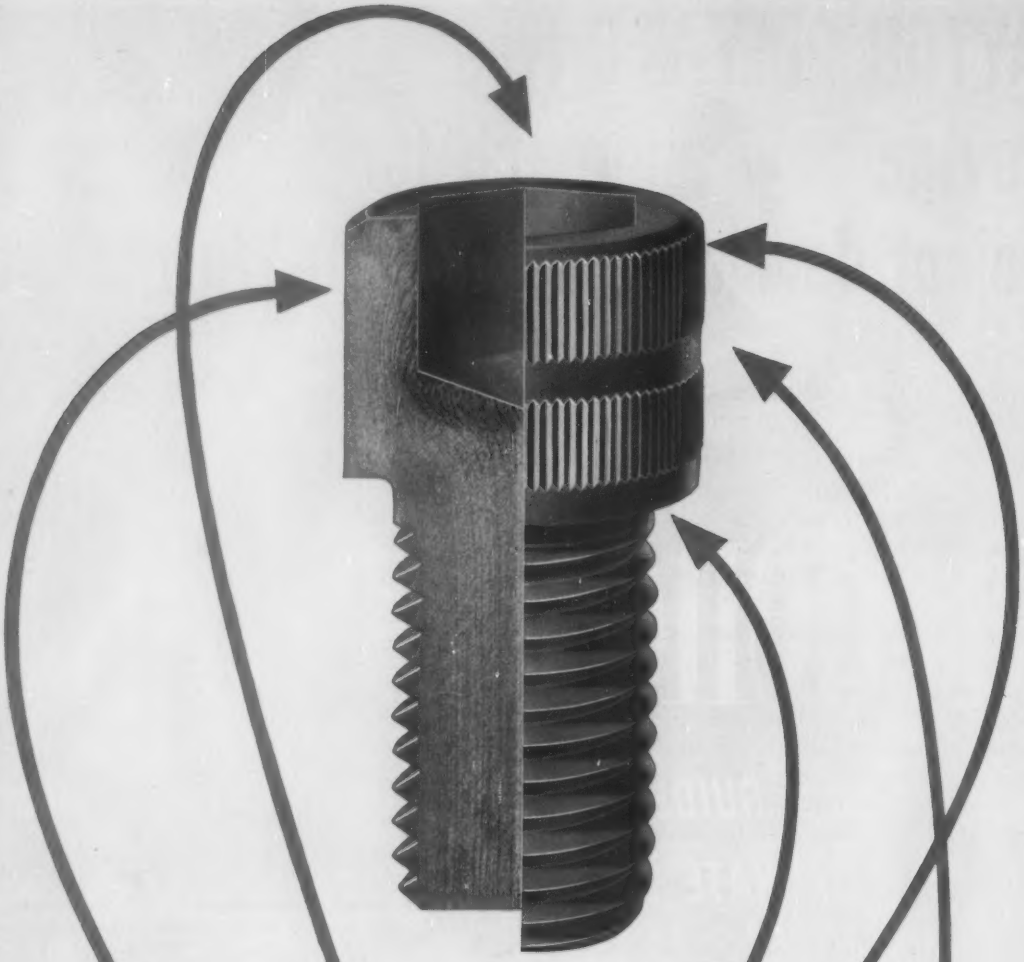
"In the space available, this drive would have been impossible with V-belts," Roy Bowers, Project Engineer, Spring Div., Borg-Warner Corp., asserts. "Our basic problem *sounded* easy enough, just get from the motor to the drum, with an 8 to 1 reduction for spin speed, simply and economically. But with V-belts we couldn't get enough wrap on the small driver to do it in one stage. However, thanks to Dayton, the Poly-V Belt solved this problem for us."

Wherever greater power delivery is required within critical space limitations, Dayton Poly-V provides the answer with narrower sheaves, shorter centers, more speed ratios and up to *50% more power delivery in ⅔ the space.* It has an extremely long service life and will withstand operating conditions that soon destroy other types of belts.





THERE IS A DIFFERENCE IN SOCKET SCREWS

Look at this cut-away of a forged socket cap screw from H-K. Notice the smooth, flowing lines of the metal fibers that give greater strength to the screw. . . look at the clean sockets scientifically proportioned for maximum strength . . . observe the controlled forged fillet under the screw head. These are features no other socket cap screw can match.

You won't see other features just as important to your production line: special analysis alloy steel heat-treated to 39-42 Rockwell "C" hardness . . . threads formed to Unified Class 3A fit . . . a new and different forging method that produces the toughest socket screws made . . . an atmospherically controlled hardening process. And behind all these features, the now famous SAME-DAY SERVICE on all standard catalog items!

Look for the difference in H-K socket screws . . . see the difference at your production line!

HOLO-KROME SOCKET SCREWS

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THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

Circle 465 on Page 19

WEAR RESISTANT
THOMSON

60 Case

AVOID the HIGH COST and difficulty of fabricating long, hard & straight parts by conventional methods!

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

ELIMINATE WEAR and REDUCE COST

60 Case is the result of over 15 years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining. *Write for literature and name of your local representative.*

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ADVANTAGES of *60 Case*

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- HARD BEARING SURFACE
- NICK-& DENT-PROOF
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

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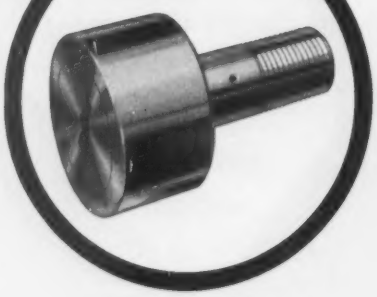
PISTON RODS • ARBORS • LEADER PINS • TIE RODS
KING PINS • AXLES • CONTROL RODS • GUIDE POSTS
MANDRELS • BEARING ROLLERS • SPINDLES

THOMSON INDUSTRIES Inc.
Dept. C-5, Manhasset, New York

Circle 466 on Page 19

PARTS HARDENED to 60 C...
increase life...reduce cost!

BEARING TIPS
by McGILL



CAMROL®
BEARINGS SIMPLIFY DESIGN and PRODUCTION

. . . add precision and reduce maintenance as cam followers, track and guide rollers

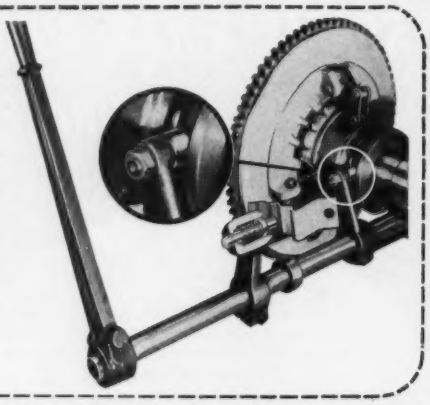
McGILL CAMROL CF Series and (sealed) SCF Series bearings offer definite design, production and maintenance advantages over "built-up" improvised bolt and roller units. Stock units with integral studs eliminate the procurement and assembly of components. They are built to high precision anti-friction bearing standards for assured machine accuracy. A full complement of rollers provide high load capacity in relatively small radial space. Specially heat treated studs provide the proper toughness to withstand shock loading. Integral seals in the SCF Series lock pre-lubrication in — contamination out.

In the CYR Series and (Sealed) SCYR Series CAMROL bearings the integral stud is replaced by an inner ring for yoke or shaft mounting.

Available in roller diameters from ½" to 4"; capacities to 20,480 lbs. at 100 RPM.

Sealed Camrol Bearings Cut Maintenance in Twin Disc Power Take-offs

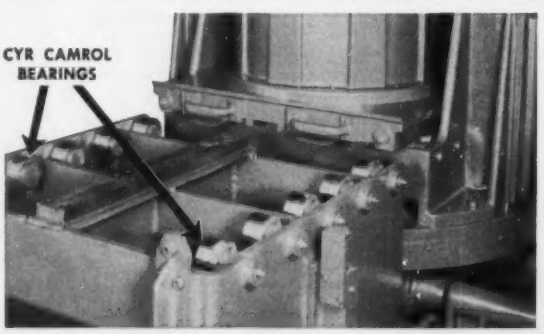
To meet the demand for a power take-off which can operate continuously for six months without additional lubrication, Twin Disc Clutch Company has produced a modified line of Power Take-Offs which use CAMROL cam followers. In the new Limited Attendance Power Take-Off, shown, the bronze throw-out collar used in the standard units is replaced with a positive clearance mechanism in the 10-inch and larger sizes. This mechanism employs CAMROL sealed cam followers which ride in an annular groove that is machined in the sliding sleeve. The followers are in contact with the sliding sleeve during engagement and disengagement handling loads up to 800 lbs. The integral seals keep the pre-lubricated bearings in dependable condition through long periods of time and prevent premature wear which may be caused by dirt and grit entering unsealed bearings.



CAMROL CYR Bearings are Trouble-Free and Accurate in NATCO Machines

The photo shows CAMROL CYR Series bearings which carry jig-type fixtures in NATIONAL AUTOMATIC TOOL COMPANY multi-spindle machines. 24 CYR bearings reduce friction and provide smooth, trouble-free, and accurate operation in these machines.

NATIONAL AUTOMATIC TOOL COMPANY reports that they have "never had a service report as to the malfunction of a MCGILL bearing."



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precision needle roller bearings

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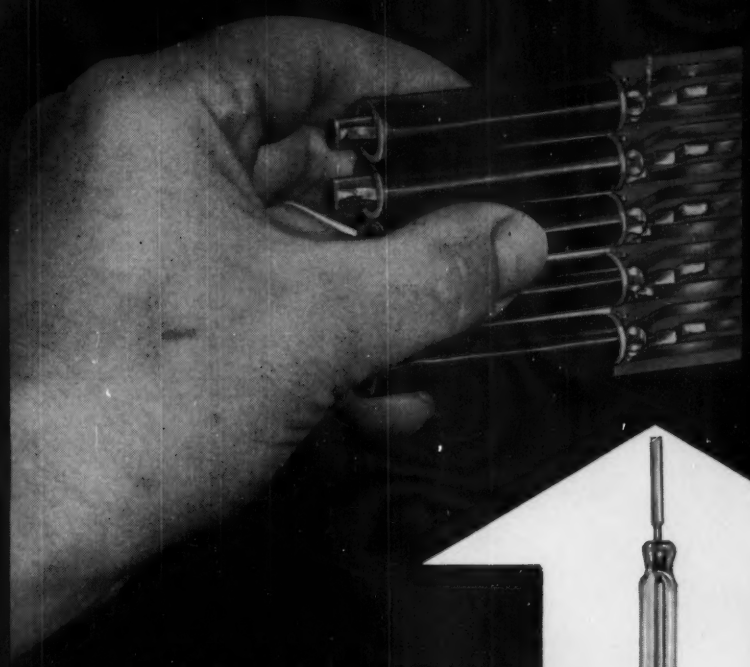
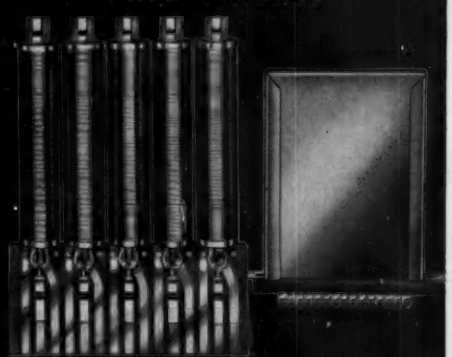
CLAREED®

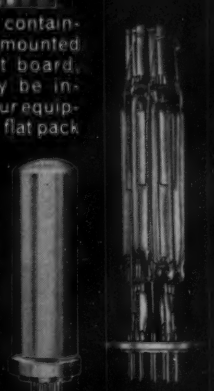
FITS INTO *YOUR* DESIGN!



PACKAGED TO MEET YOUR REQUIREMENTS



Here five relays, each containing two switches, are mounted on a printed circuit board. This assembly may be inserted directly into your equipment or enclosed in a flat pack container.



These six switches are clustered to form the core of a single electromagnetic coil, and encased in a cylindrical steel container.

ACTUAL SIZE

Basic element of CLAREED relays is this switch capsule. A pair of magnetically operated contacts is hermetically sealed in an atmosphere of inert gas. The capsule combines extreme simplicity with high reliability and long life. It has excellent low-level characteristics.

Circle 468 on Page 19

CLAREED Sealed Contact Reed relays put you . . . the designer . . . in the driver's seat. They are simple in design, flexible in assembly. They are packaged and mounted to comply with *your* mechanical design configuration . . . even on your own circuit board. CLAREED relays are ideal components for transistor-drive applications, computers, data-processing and other high speed equipment.

Contacts are hermetically sealed in inert gas. Tens of millions of operations are assured since contact contamination is completely precluded. Hundreds of millions of operations are possible when operated up to ½ rated load.

If you use relays, it will pay you to know all about CLAREED . . . an entirely new concept in relay design. Address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC-5.*

CLARE

When only the best is good enough

Trailer axles take shape as automatic butt welder upset flash welds spindles to each end of 40-inch lengths of Pittsburgh Steel Co.'s mechanical tubing at Kenton, Ohio, plant of Rockwell-Standard's Transmission and Axle Division.

An Axle Axiom: Long Service Life

Pittsburgh Steel Company's Seamless Tubes Give Years of Service in Rockwell-Standard Corp.'s Trailer Axles

Mechanical tubing from Pittsburgh Steel Company covers a lot of ground —in truck trailer axles.

Pittsburgh Steel is a prime supplier of mechanical tubing to the Kenton, Ohio, trailer axle plant where the Transmission and Axle Division of Rockwell-Standard Corp. makes trailer axles for every major trailer manufacturer.

• **Uses C1040 Grade Tubing**— Rockwell-Standard uses AISI C 1040 grade hot rolled tubing, ranging from 4-inch outside diameter with a 3/16-inch wall thickness to tubing 6 inches in diameter with 1/2-inch wall.

Typical tubing shipped to Rockwell-Standard is made of fine grained steel in a uniform hardness range which enables the customer to develop the final physical properties he wants by heat treatment.

Pittsburgh Steel tubing performs satisfactorily in Rockwell-Standard's processing operations and satisfies the ultimate user—the trailer manufacturer —because we meet these requirements from tube to tube and from shipment to shipment.

Hardness is a prime requirement because lack of uniformity would require more costly operations at Rockwell. With Pittsburgh Steel tubes, heat treating can be standardized with predictable results.

Weldability scores high. Long service life of trailer axles demonstrates the weldability of Pittsburgh Steel's tubing. With an average of

10 welds in every axle, welds have to be good. Strength and porosity tests prove they *are* good.

Freedom from scale helps promote predictable results from heat treating. Scale would produce steel with different rates of hardness after heat treating. No de-scaling operation is necessary with Pittsburgh Steel tubes.

Uniformity of wall thickness helps to prevent warping of axles in oil quenching and eliminates re-straightening in many cases or holds such operations to a minimum.

• **Tubing first is cut to length** by Rockwell to make axles which will track either 70 inches or 71½ inches, both standard widths. Forged spindles then are flash upset welded, one on each end of the tube. Welds are made simultaneously.

Next, tube and spindle assemblies pass through a high heat furnace on a moving conveyor. For the two hours each assembly is in the 60-foot long furnace it is subjected to a temperature of 1500 degrees F. Each 1½ minutes, an assembly emerges from the furnace to be oil quenched.

To temper the assemblies to the desired Brinell hardness, each passes through a draw furnace where it soaks for an hour in 1000 degrees F.

Rockwell-Standard wants a rating of 269 to 321 for spindles and 218 to 269 for tubing.

Axles then are cleaned by shot in a Wheelabrator and moved to the Machine Shop. Spindles are machined to final contours, welding flash is removed and threads are machine rolled.

• **After accessories,** like spider brackets, diaphragm brackets and cams are welded to the axle, stress relief follows to ease strains set up by welding. An hour's treatment at 900 degrees F. does the trick.

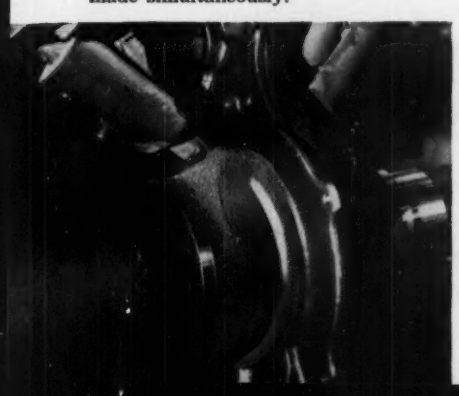
On the final assembly line, each axle gets a brake system fitted to the brake spiders. Nylon support brackets and grease fittings are added, the axle is greased, painted and moved to the shipping platform.

Pittsburgh tubing, five inches in diameter, is being ground to 4.880 inches to meet specifications.

You don't have to be a manufacturer of axles to enjoy the same benefits that Rockwell-Standard gets from Pittsburgh Steel tubing.

Any tube user who wants to lower production costs while making a better product can profit by using Pittsburgh Steel tubular specialties.

You get the physicals you want and you can expect better performance in fabrication. Talk to a Pittsburgh Steel man today. You'll find him in one of the district offices listed below.



Close-up of brake spider being submerged arc welded. Four welds are made simultaneously.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Ward Steel Service Company
Dayton, Ohio

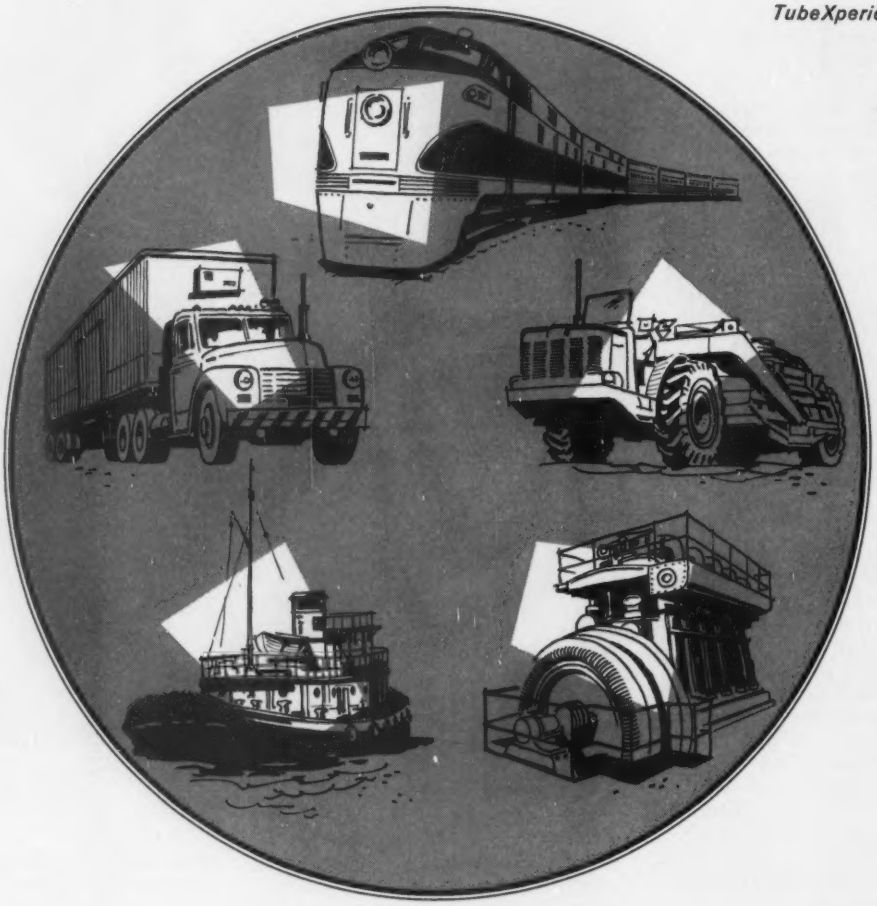
Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta · Chicago · Cleveland · Dayton · Detroit · Houston · Los Angeles · New York · Philadelphia · Pittsburgh · Tulsa · Warren, Ohio

Circle 469 on Page 19



Feedlines for hungry horsepower . . . diesel fuel injection tubing by Superior

Fuel injection systems are the heart of thousands of diesel-powered trucks, locomotives, roadbuilding equipment, electric generators, and marine power plants. The tubing that conveys the fuel from injection pump to nozzle assembly is an important component. It must resist the stresses of pressure and vibration, yet be ductile enough to be cold swaged and upset and be cold formed into loops and bends without excessive springback. It must have a clean ID, tremendous burst strength, and high fatigue resistance. Superior diesel fuel injection tubing is just such a premium product.

Type C-1008 and Type MT-1010 carbon steel tubing are most commonly specified for this application, but alloy and stainless steel tubing for pressures above 9000 psi and greater corrosion resistance is available. Superior also makes tubing for many other applications—supplies both general and special purpose tubing for aircraft, missiles, electrical, electronic, chemical, hydraulic, dairy and nuclear, to name a few. For complete information, write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

SOME REASONS WHY SUPERIOR FUEL INJECTION TUBING IS A PREMIUM PRODUCT

- It will handle pressures to 9000 psi, is hydrostatically tested to various pressures according to specification
- It is cold drawn, dead soft annealed, and seamless
- It is ID conditioned to remove fissures and other defects
- It is free from ID radial cracks deeper than .005 in. or 5% of wall thickness, whichever is less
- It is annealed at finish in controlled atmosphere furnaces to produce a soft, ductile and scalefree material
- Fracture tests are performed when requested

Superior Tube

The big name in small tubing

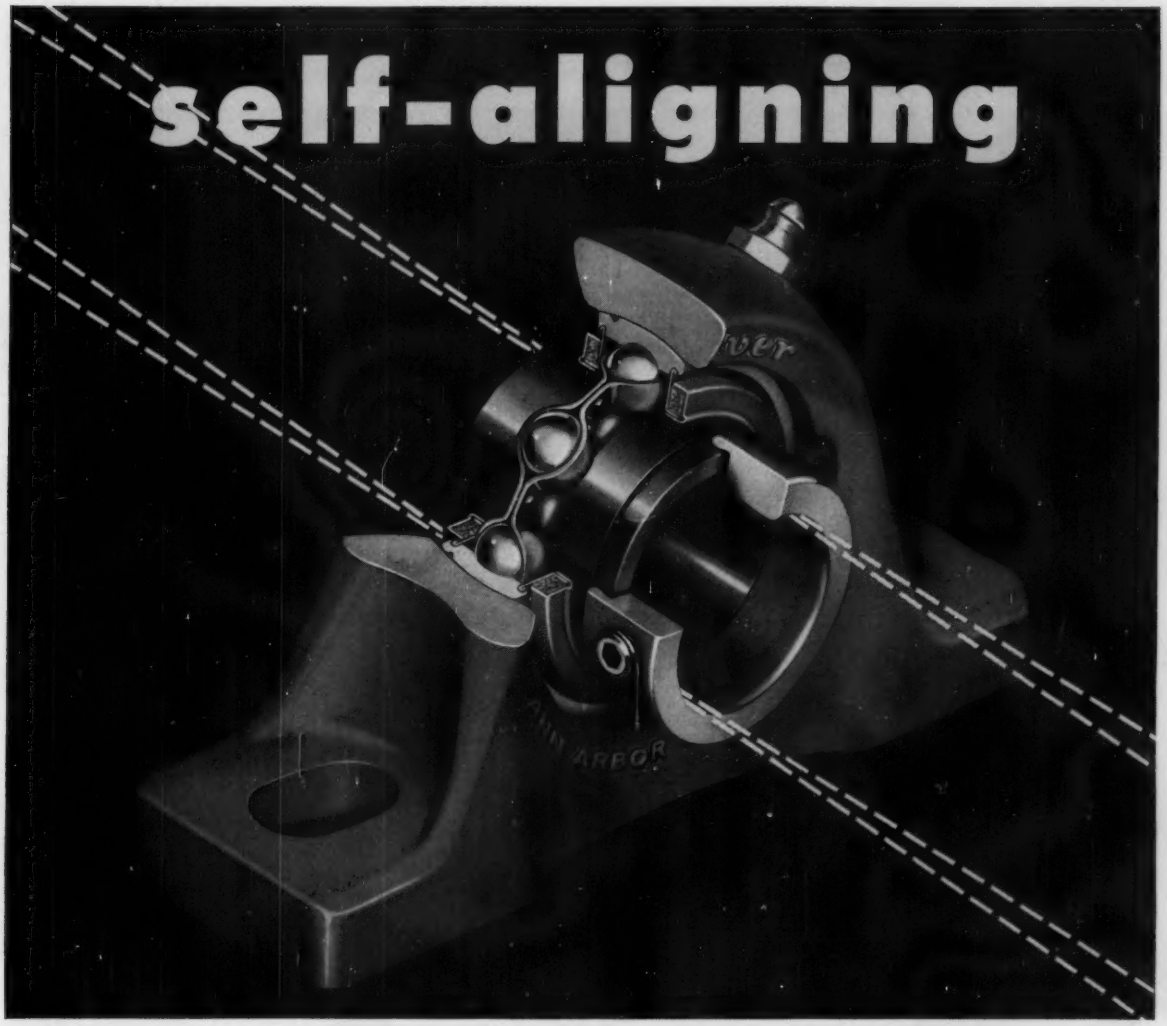
NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

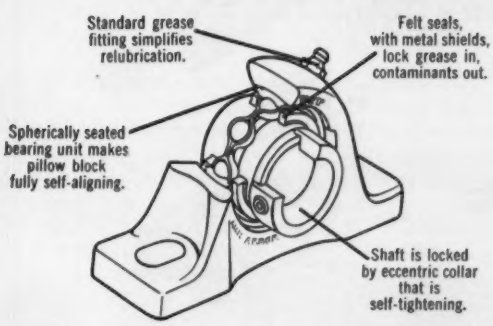
West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Circle 470 on Page 19

self-aligning



hoover quality PILLOW BLOCK BALL BEARINGS


Standard grease fitting simplifies relubrication.
Felt seals, with metal shields, lock grease in, contaminants out.
Spherically seated bearing unit makes pillow block fully self-aligning.
Shaft is locked by eccentric collar that is self-tightening.

Simplify bearing application problems caused by inaccuracies of assembly or machining of equipment. Use *Hoover Quality* SP series pillow block ball bearings that adjust automatically to shaft misalignment in any direction.

Installation is quick and easy. Elongated bolt holes in the base of the pillow block simplify mounting. Eccentric collar forms a self-tightening shaft lock.

Hoover Quality features assure long, trouble-free life under normal duty and shock load conditions. SP series pillow block, flange bearings and machine units are available in shaft sizes from ¾" to 2 15/16".

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Zone Sales Offices and Warehouses | 8581 South Chicago, Chicago 17, Illinois
290 Lodi Street, Hackensack, New Jersey
2020 South Figueroa, Los Angeles 7, California

Hoover Ball and Bearing Company
5400 South State Road, Ann Arbor, Michigan MD-4

☐ Please send information on SP series pillow blocks.

☐ Have your representative call.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 471 on Page 19

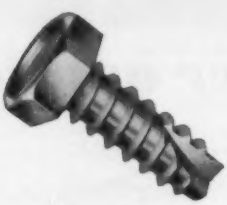
ELCO®

TYPE 1

THREAD-CUTTING SCREWS

The use of Thread-Cutting Screws means lower costs on the assembly line. Such savings, however, may be lost unless the right type of screw is selected, and unless the buyer is assured that the screws he gets are of uniform hardness with correctly-shaped threads and sharp cutting edges. *For such assurance — buy from ELCO.*

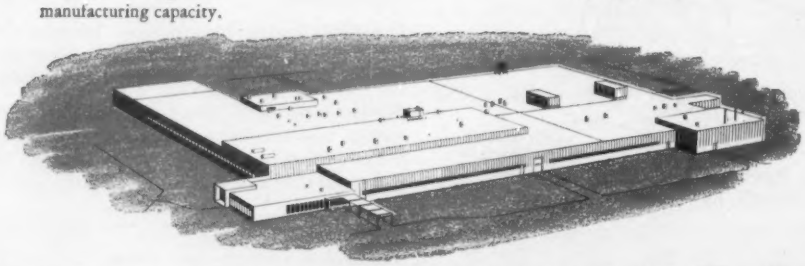
TYPE 23



TYPE 25

NEW PLANT

You are cordially invited to visit us in our new factory — 242,000 sq. ft. of busy and well-organized manufacturing capacity.



ELCO TOOL AND SCREW CORPORATION

1119 SAMUELSON ROAD, ROCKFORD, ILLINOIS

thanks to *automatic* xerography...

REDUCE DRAWING-STORAGE SPACE UP TO 95%

Save $20,000 to $100,000 yearly on time, labor, and materials!

How would you like to reduce—by as much as 95%—the storage space you now allot to active and inactive engineering drawings?

In so doing, you'll also reduce time and labor costs dramatically. Savings as high as $100,000 a year can be achieved because of a spectacular breakthrough in storage and reproduction techniques.

This development, called a unitized microfilm system, has three basic steps: microfilming original drawings or changes; mounting individual frames into diecut apertures of data-processing cards; and, from the cards, automatically enlarging the microfilmed drawings by xerography, fast and economically, in a XeroX® Copyflo® 24C continuous printer.

Dry, positive prints, translucent intermediates, or offset paper masters emerge at the rate of 20 feet a minute. They are automatically cut, and ready for immediate use.

The aperture cards, which may be machine-sorted for any combination, are stored in miniature working files, occupying only a tiny fraction of the space required by blueprints, intermediates, or originals.

There is no refiling. The quality of xerographic prints is superbly high, yet they are so inexpensive that engineers are urged to discard them after use.

Unitized microfilm systems offer many other striking economies in time, money, and materials. Our booklet X-300, showing the many benefits, is yours for the asking. Write HALOID XEROX INC., 60-111X Haloid St., Rochester 3, New York. Branch offices in principal U. S. and Canadian cities.

Overseas: Rank-Xerox Ltd., London.

See us at Booths 63-64

National Microfilm Association Convention

NEW YORK CITY • APRIL 19-21

PUSH THE BUTTON...AND COPIES FLOW!

HALOID XEROX®

Circle 473 on Page 19

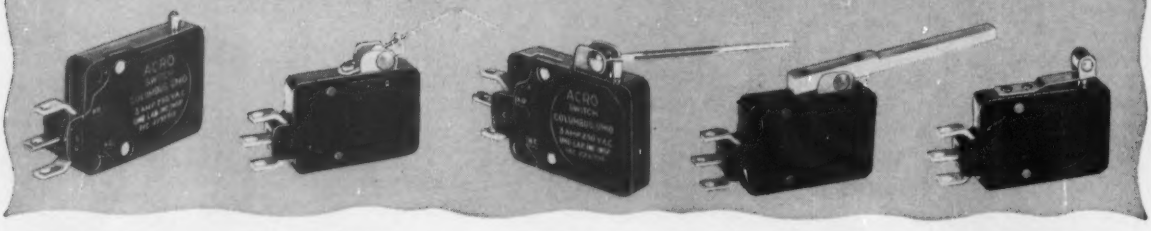
Does the miniature or sub-miniature switch you need have to function at minimum operating pressures? *Two Acro models meet your toughest electrical and mechanical requirements. Model Coin M operates on pressures as low as 2.5 grams; Model Z as low as 2 oz. pressure.*

These two dependable lines of Acro miniature and sub-miniature switches all feature Acro's famous rolling spring principle, and are available with a complete line of actuators. Most switches in these two series can be easily ganged for multi-pole applications.

Acro's Coin M switches, for instance, are only 9/32" thick — and function perfectly wherever a precision, snap-action switch is required. Most common applications are in timers, control circuits, and vending machines.

Acro's model Z series — some so small they can hide behind a dime — features 24 types of actuators. All are built to conform to MS 25085 and Mil 6743. Gold-flashed contacts assure long shelf life.

model coin M switches — U.L. Approved — 3 Amp 250 V.A.C.



1CMD1-2AXX Basic Switch-Pin Plunger

Operating Characteristics

Operating force	20-27 gms.
Release force	12 gms. min.
Pretravel	.040 max.
Overtravel	.025 min.
Movement diff.	.030 max.

1CMD1-2AXX-A22 Wire Leaf Actuator

Operating Characteristics

Operating force	2.5 gms. max.
Movement diff.	.50" max.

1CMD1-2AXX-A24 Flat Leaf Actuator

Operating Characteristics

Operating force	2.5 gms. max.
Movement diff.	.50" max.

1CMD1-18AXX-A27 Nylon Leaf Actuator

Operating Characteristics

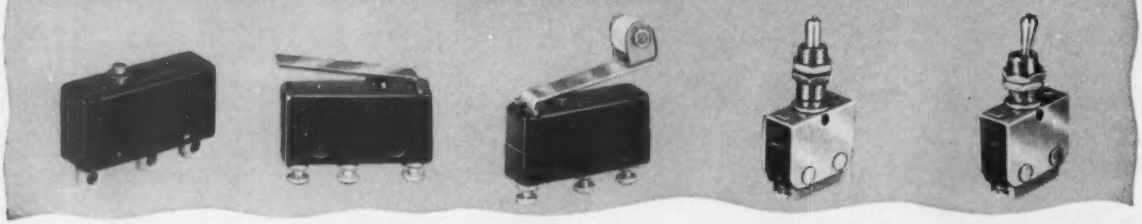
Operating force	6.0 gms. max.
Movement diff.	.30" max.

1CMD1-1AXX-A23M Roller Leaf Actuator

Operating Characteristics

Operating force	5-8 oz.
Release force	2 oz. min.
Pretravel	.040" max.
Overtravel	.025" min.
Movement diff.	.030" max.

model Z subminiature switches — U.L. Approved 5 Amp — 120-240 V.A.C.



ZD-0024 Standard Post Terminal

Operating Characteristics

	.010" Gap
Operating force	145 gms. max.
Release force	50 gms. min.
Movement diff.	.004" max.
Pretravel	.020" max.
Overtravel	.010" min.

ZLD-0035 Straight Leaf Actuator

Operating Characteristics

	.010" Gap
Operating force	2 oz. max.
Release force	½ oz. min.
Movement diff.	.015 max.
Pretravel	3/32 max.
Overtravel	.045 min.

ZLD-0033 Roller Leaf Actuator

Operating Characteristics

	.010" Gap
Operating force	2 oz. max.
Release force	½ oz. min.
Movement diff.	.015 max.
Pretravel	3/32 max.
Overtravel	.045 min.

ZPD-0044 Single Small Push Button Overtravel Actuator

Operating Characteristics

	.010" Gap
Operating force	10 oz. max.
Release force	1 oz. min.
Movement diff.	.030 max.
Pretravel	.050 max.
Overtravel	.125 min.

ZTD-0041 Single Panel Mount Toggle Actuator

for detailed specifications and prices write for catalogs "CM" and "Z".

Free engineering service. Our engineers will be happy to pit their professional experience against your tough switching problem. Just tell us what it is . . . we'll recommend ways to solve it. No obligation, of course.

Manufacturers of a complete line of load-tested precision snap-switches and relays.

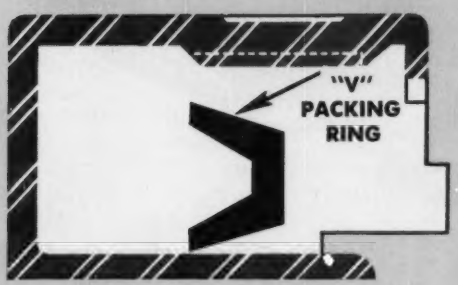
RELAYS ACRO SWITCHES

"OUR 21st YEAR"

ACRO DIVISION Robertshaw

COLUMBUS 16, OHIO

GITS HH-TYPE SEAL SERIES



VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 475 on Page 19

GITS

Extra Flexibility For Your Seal Applications!

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope—with your choice of the five seal packing arrangements illustrated at left—permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements of the aircraft and missile industry.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

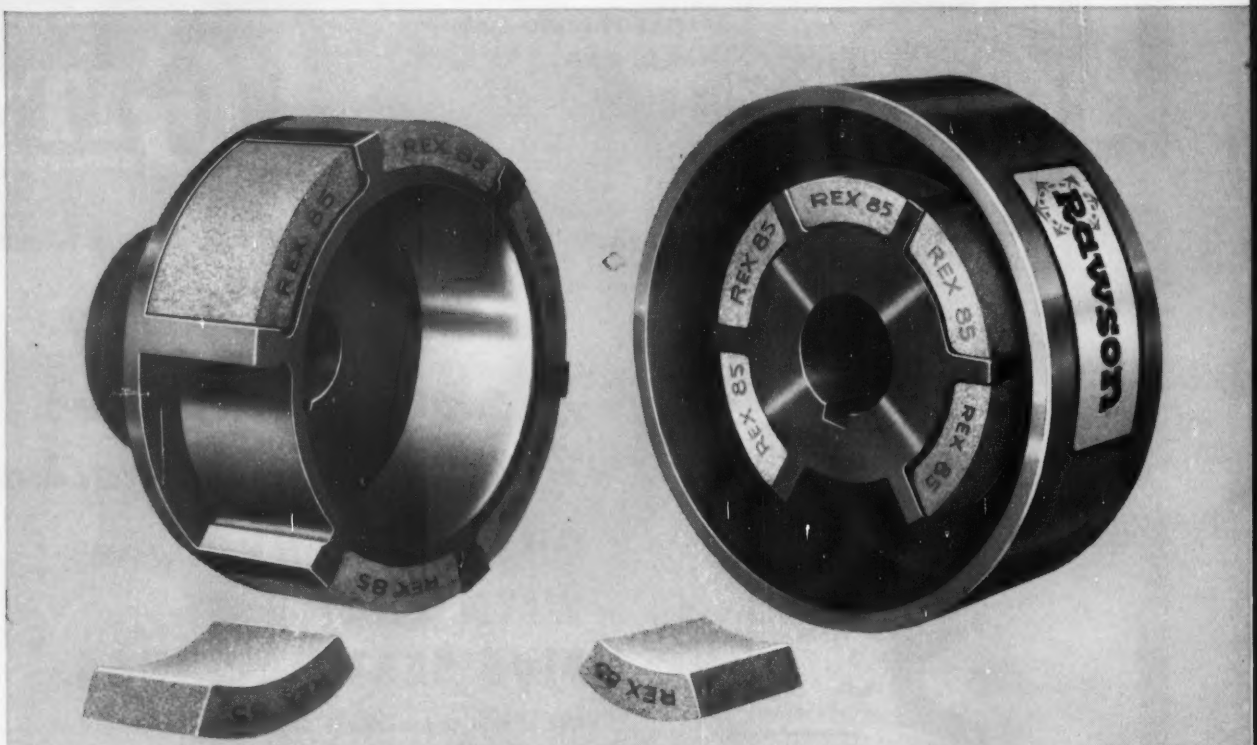
Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

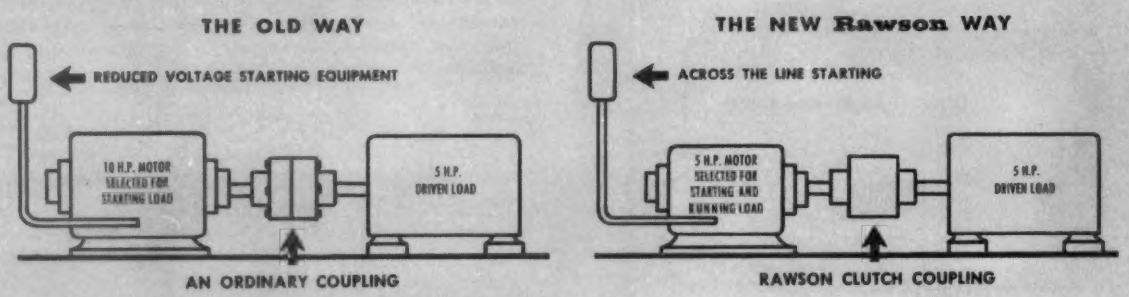
GITS BROS. MFG. CO.

1868A South Kilbourn Avenue • Chicago 23, Illinois

NEW! *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*

NOW! You Can Use Smaller Motors Improve Motor Performance




THE OLD WAY
REDUCED VOLTAGE STARTING EQUIPMENT
10 H.P. MOTOR SELECTED FOR STARTING LOAD
5 H.P. DRIVEN LOAD
AN ORDINARY COUPLING
THE NEW Rawson WAY
ACROSS THE LINE STARTING
5 H.P. MOTOR SELECTED FOR STARTING AND RUNNING LOAD
5 H.P. DRIVEN LOAD
RAWSON CLUTCH COUPLING

Check These Additional Features of

- Exclusive all-metal shoes permit higher operating temperatures, assure longer life.
- For power applications up to 2,000 horsepower, drive in either direction.
- Fluid-smooth starting without the power loss of fluid types at full load R.P.M.
- Protects the most delicate equipment by eliminating starting shock.
- No dangerous prolonged surge current when high-inertia equipment is started.
- All-metal shoes never need adjusting, entirely mechanical operation assures longer life.

. . . Lower Starting Equipment Costs . . .

. . . Secure Automatic Overload Protection

With Rawson Centrifugal Clutches

The Rawson is an all-metal centrifugal clutch that drives in either direction and provides: *no-load* starts for motors—cushioned starting of equipment at predetermined R.P.M.—automatic overload protection—slip-free power at normal operating speeds—rugged design for applications up to 2,000 horsepower.

Results: "no-load" starting decreases acceleration time and starting current—across-the-line starting can be used instead of costly reduced voltage equipment—based on lower starting load, smaller motors can often be employed—cushioned starting of high inertia loads frequently permits using NEMA B or standard squirrel-cage motors instead of expensive special high-torque motors—delicate equipment is protected by eliminating starting shock—jamming or overloading of driven equipment will cause the clutch to slip, providing protection for motor.

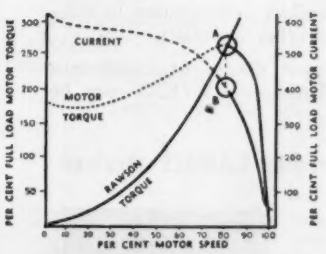
Rawson clutches function as direct-drive clutch-couplings (in-line, shaft-to-shaft connection) or as indirect-drive clutches through V-belts, chains or gearing. They can be furnished with delayed engagement for standby or dual drive installations.

Rawson clutches are simple in design, they never require adjustment, and are entirely mechanical in operation for trouble-free performance. For higher efficiency, lower costs, reduced maintenance and full protection for even the most delicate equipment, specify Rawson centrifugal clutches and clutch-couplings.

Ask your Rawson distributor or write directly to us for your free copy of Rawson Catalog No. 141.

FORMSPRAG COMPANY
23603 Hoover Road, Dept. 109
Warren (Detroit), Michigan

FORMSPRAG COMPANY

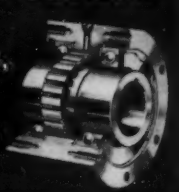


Typical torque and current characteristics of a standard NEMA B motor. Because Rawson clutch does not fully engage until after peak torque speed "A" is reached, motor acceleration time is much faster, peak current period is greatly decreased and motor operates more efficiently "B". Thus, smaller motors and across-the-line starting can be used.

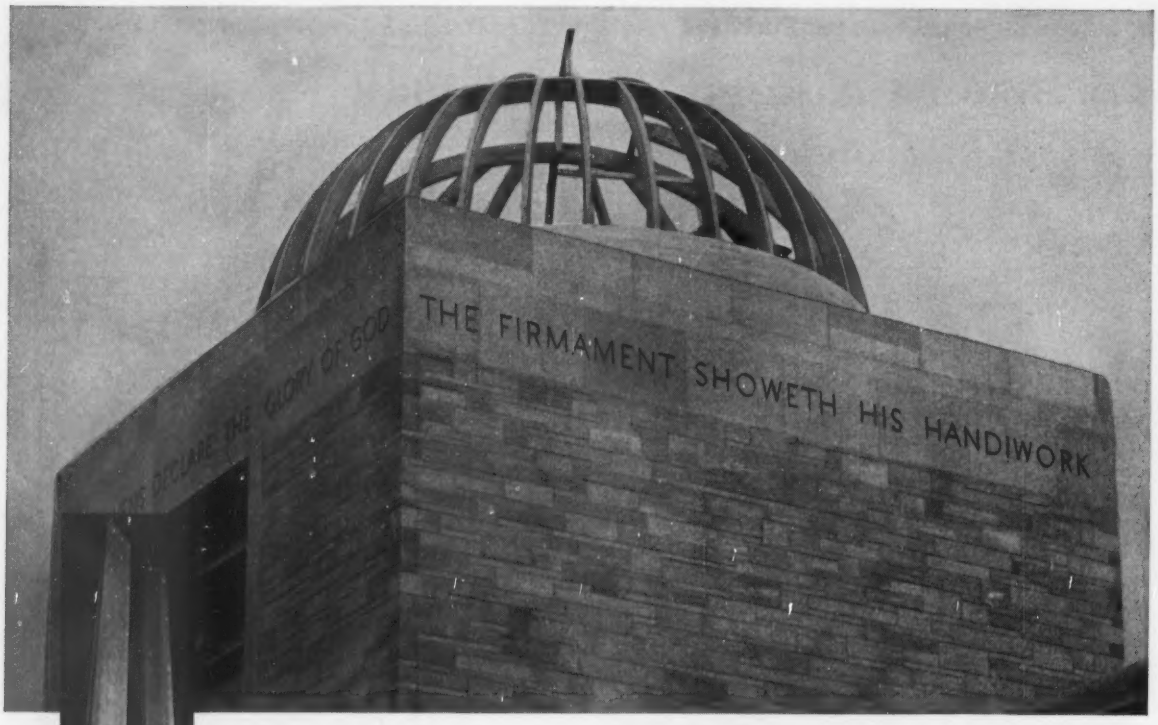
Rawson Clutches

- **No-load starting reduces motor acceleration time to a fraction of a second.**
- **Full power at normal operating R.P.M.—No Slip, No Power Loss, No Heat.**
- **Rugged design and all-metal construction keep maintenance requirements to a minimum.**

THERE IS A FORMSPRAG OVER-RUNNING CLUTCH FOR EVERY OVER-RUNNING, INDEXING & BACKSTOPPING APPLICATION



Modern Formsprag over-running clutches are universally used by automotive, aircraft and other industries. They provide greatest torque for size and weight, higher precision and no measurable backlash. Torque capacities range from 50 lbs. in. to 136,500 lbs. ft. Standard bore sizes from ¼" to 12". Our engineering department will design special Formsprag clutches for your unusual applications. Write for your copy of Formsprag catalog.



from deflector bars...to observatory domes...

GAMBLE solves problems with WOOD!

PROBLEM: Solid wood conveyor deflector bars were splitting and breaking from repeated impact of conveyed objects, causing downtime expense.

SOLUTION: Gamble wood engineers developed a *laminated hickory* deflector bar—thinner and more resilient, yet with greater and more uniform strength (due to lamination and the characteristics of hickory).

PROBLEM: Butler University, Indianapolis, needed a hemispherical dome for its J. I. Holcomb Observatory. The material for the 360-degree-rotating dome had to offer maximum dimensional stability *plus* beauty in keeping with the overall design.

SOLUTION: Gamble Brothers provided curved, laminated, wooden ribs for the 24-foot Observatory dome, and another giant "umbrella frame" for the Planetarium dome.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

PEAK POWER OUTPUT FOR HEAVY-DUTY EQUIPMENT...

HYDRA-DRIVES®

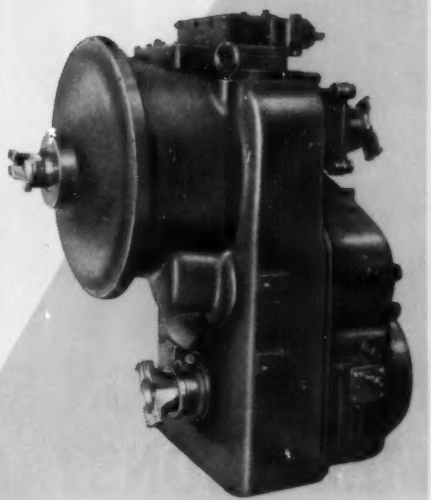
POWER SHIFT TRANSMISSIONS and TORQUE CONVERTERS

Rockwell-Standard's Hydra-Drives units make hard work easy for heavy-duty equipment. The result . . . smooth, efficient, economical operation. A torque converter and 4-speed transmission in one compact package, the Hydra-Drives Power Shift Transmissions have been proved in hundreds of vehicles. They eliminate engine lugging and heavy shock loads. A 3-to-1 torque multiplication makes starting fast and effortless—even with heaviest loads.

Just a flip of the operator's lever accomplishes power shifts without interruption of the power flow. Automatic features of the converter and ease of power shifting simplifies operator training and lengthens vehicle life.

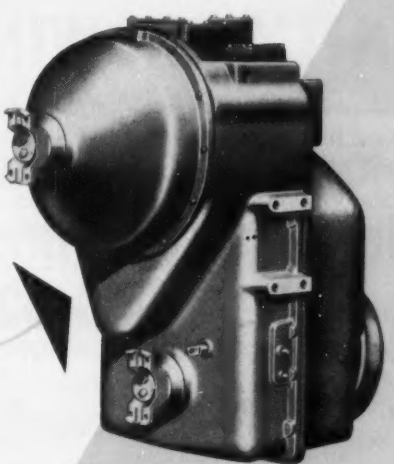
With four speeds forward and reverse, the Hydra-Drives Power Shift Transmissions are ideally suited for vehicles which must travel in both directions during a normal work cycle.

Hydra-Drives Torque Converters are the simplest, most efficient made. They can be matched with any transmission for easier, more efficient operation.



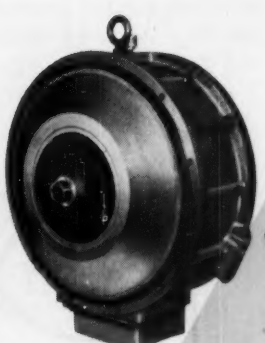
HYDRA-DRIVES BDB Transmission

- Four speeds forward and reverse.
- Full power shifting.
- For equipment up to 175 h.p.



HYDRA-DRIVES CDB Transmission

- Four speeds forward and reverse.
- Power shift in each range both forward and reverse.
- For equipment up to 250 h.p.



HYDRA-DRIVES Torque Converter

- 3-to-1 torque multiplication.
- Available separately, or with Hydra-Drives Transmission.
- For vehicles up to 500 h.p.

HYDRA DRIVES

ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

Products of **ROCKWELL-STANDARD** Corporation

Circle 478 on Page 19

ENJAY DELIVERS 1,000,000th LONG TON OF BUTYL!

PRODUCTION FACILITIES INCREASED TO MEET CONSTANTLY GROWING DEMAND

There have been many elastomers developed since the first commercial ton of Butyl was used in 1943, but no other rubber, synthetic or natural, offers so many outstanding properties for so many applications.

Plant expansion plans announced recently will increase butyl production capacity some 50 percent by 1961 and, at today's rate of consumption, the two million-ton mark will be reached within the next six or seven years. Two new additions to the butyl product line, Chlorobutyl and Butyl Latex, will soon be available in commercial quantities.

VERSATILE ENJAY BUTYL'S OUTSTANDING PROPERTIES MAKE IT SUPERIOR TO OTHER RUBBERS FOR MANY APPLICATIONS. SOME ADVANTAGES:

- **RESISTS TEAR AND ABRASION** ... used in the new and revolutionary all-butyl tire.
- **STANDS UP AT HIGH TEMPERATURE** ... used in steam hose and tire curing bladders
- **HAS EXCELLENT ELECTRICAL PROPERTIES** ... used in high voltage cable insulation
- **IS IMPERMEABLE TO GASES** ... used in virtually all rubber air-holding applications
- **HAS WIDE RANGE OF DYNAMIC PROPERTIES** ... used in over 100 applications on the modern automobile
- **DISPLAYS OUTSTANDING CHEMICAL RESISTANCE** ... used for the storage and shipment of many chemical and commodity products
- **WITHSTANDS EXPOSURE TO SUN AND WEATHER** ... used in irrigation pipe and roof coatings.

Want to find out fast, how versatile Butyl can improve your product? Call or write the nearest Enjay office.

ENJAY® BUTYL

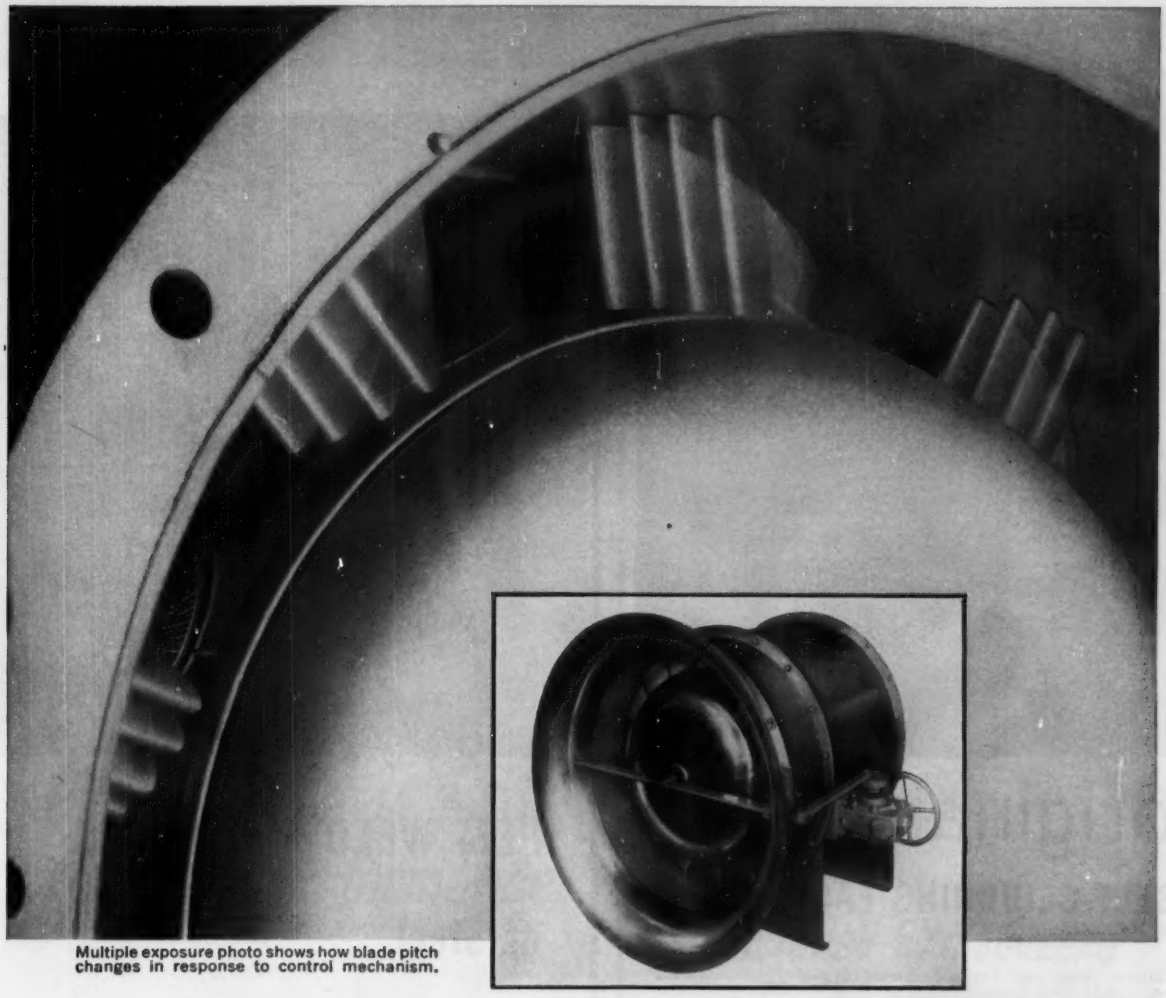
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC.

15 West 51st Street, New York 19, N.Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa • Toronto

Circle 479 on Page 19



Multiple exposure photo shows how blade pitch changes in response to control mechanism.

Automatic Adjustment of Air Supply to CO_2 Concentration, Temperature or Humidity with Joy Controllable Pitch Axivane® Fans

The blade pitch on Joy Axivane Fans can be changed automatically while the fan is running, varying the air volume as much as ±20%. The controlling mechanism can be linked to a sensing device to make air volume respond to a change in ambient temperature, humidity, concentration of a gas, or any of a number of conditions.

Controllable Pitch Joy Axivane Fans are ideal for ventilation of vehicular tunnels and work areas in which noxious gases tend to collect, maintaining air cooled equipment at an even temperature, stabilizing moisture content in an area, or any application requiring a variable supply of ventilation air.

Write for complete details on how Joy Controllable Pitch Axivane Fans can be made to suit your particular situation. Ask for bulletin 289-64-B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 480 on Page 19

PEM FIRST NAME IN

Slots (or corrugations) prevent fastener from turning
Sheet remains flush on opposite side. No swaged rim projects
Clinching ring squeezes sheet material around back-tapered shank, securely locking fastener

THE original SELF-CLINCHING FASTENER

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

THE ANSWER TO PRODUCTION FASTENING—This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

INSTALLED BY A SQUEEZE with the greatest of ease (without special tools) Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation . . .

THEY SAVE THEIR COST MANY TIMES OVER . . . in time, labor and special equipment. PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .030" and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #2 to ¾". Also made as Blind Fasteners for pressure seal applications.

For complete information, write on your letterhead for Bulletin No. CL359 and sample.

Circle 481 on Page 19

Engineered projections. No burnouts in thin sheets
Round body—no indexing. Compact. Fits on narrow flanges
Self-locating pilot. Simplified electrodes
Shank protects threads from weld spatter. No retapping

specify PEM WELD FASTENERS of Steel or Stainless Steel

PEM Weld Fasteners are designed for production . . . Faster Assembly . . . Lower Equipment and Labor Costs . . . and corrosion resistance, too, when required.

SHANK locates and protects threads against weld splatter . . . eliminates retapping.

ENGINEERED PROJECTIONS prevent burnouts in thin sheets.

SIMPLE ELECTRODES . . . no pilots required.

ROUND COMPACT SHAPE . . . no indexing in assembly . . . fit on narrow flanges.

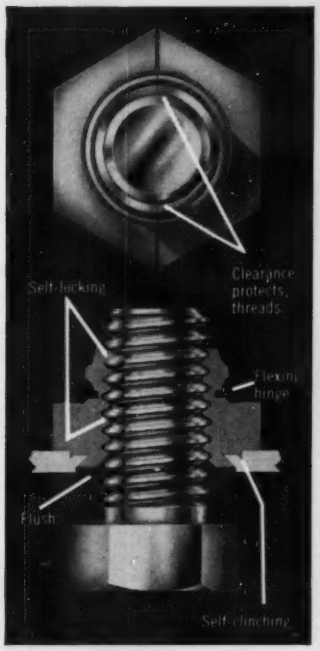
Write on your letterhead for Bulletin WN-1158 and sample for trial.

Circle 482 on Page 19

PENN ENGINEERING & MANUFACTURING

New York (Belle Harbor, L.I.)—Neptune 4-7103
Chicago (Forest Park, Ill.)—Forest 6-4971
Detroit—University 3-5189
Cincinnati—Humbolt 1-4261
Indianapolis—Clifford 1-4020
Milwaukee—Bluemound 8-6118

CAPTIVE FASTENERS



ALL-METAL SELF-LOCKING SELF-CLINCHING PEM NUTS

are tops in performance

Combine two essential functions in one lightweight, low-cost unit.

The self-clinching feature is the same tried and proven original PEM design, recognized by industry as the answer to production fastening. It is installed by a squeeze into sheet metal, too thin to thread, by standard pneumatic, hydraulic or mechanical presses.

The all-metal, self-locking feature offers distinct lock-nut design improvements required for top performance under temperature, vibration and stress requirements of such high-reliability services as missile, rocket, aircraft and electronic components.

Exclusive Design • Outstanding Advantages: The All-Metal, Self-Locking features of the new PEM Nut speak for themselves:

ONE SLOT design: two rugged semi-circular jaws with inherent flexing action—far stronger than several less-supported segments.

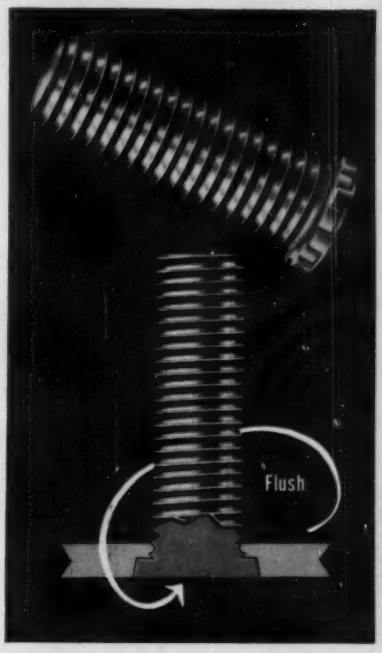
FLEXING HINGE: a machined slot at the base of each semi-circular jaw retains inherent flexing action, permanently. Guarantees against relaxation and loosening in severe service. Permits reuse, repeatedly, without diminishing self-locking efficiency.

PROTECTS THREADS: fewer segments—plus relief of cutting edges of single slot design, to provide clearance, insures that *no* cutting edges come in contact with the screw.

Made in #303 stainless steel (temperatures to 800° F); steel (temperatures to 500° F); high strength aluminum alloy (temperatures to 250° F); in sizes from #4-40 to #10-32 for use in aluminum, brass, copper, and cold-rolled steel sheets of thicknesses from .040 up and stainless steel sheets from .050 up.

Write on your letterhead for literature and sample for test.

Circle 483 on Page 19



now PEM SELF-CLINCHING CAPTIVE STUDS

"installed by a squeeze with the greatest of ease"

Answering Industry's demand for a captive stud employing the same unique design as the line of PEM captive Self-Clinching Nuts—which ushered in production fastening in sheet metal assembly—Penn Engineering and Manufacturing Corp. has produced the PEM flush-head self-clinching stud.

Saving time, labor, weight on tough assembly jobs, these studs make a surprisingly simple operation out of what formerly was accomplished by various slow and costly makeshift assembly methods, such as welding.

You simply place the studs—one or several at a time—into drilled or punched holes in the panel and squeeze them into place with any standard pneumatic or oil-hydraulic squeezer or mechanical press.

The squeezing action embeds the head projections into the sheet—the displaced metal flowing smoothly and evenly around the back-tapered shank and annular groove to securely lock the stud into the panel with high torque and pushout resistance.

Try them. Write on your letterhead for literature and sample. Sizes from #4-40 to 5/16-18. Carbon steel or #305 stainless steel, for use in various aluminum alloys, brass, copper, cold rolled steel and similar sheets in thicknesses from .040 up.

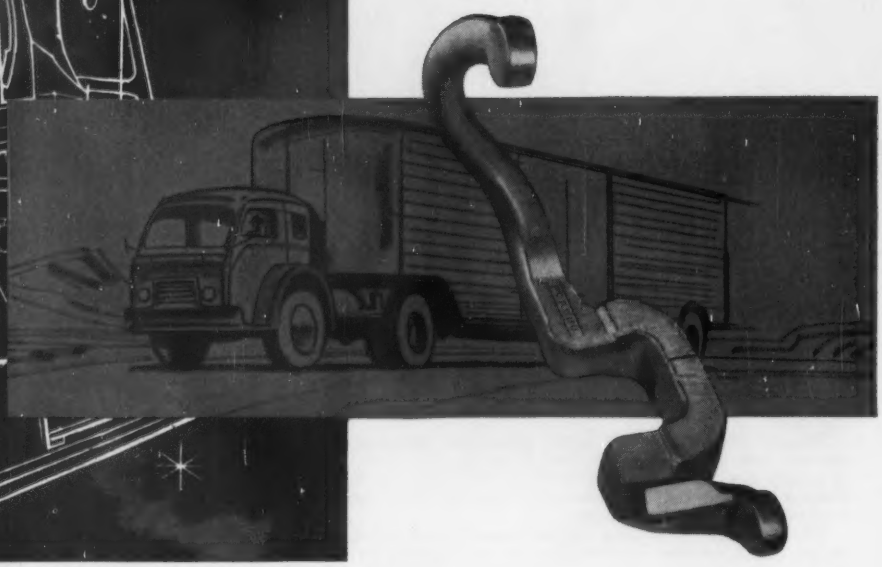
Circle 484 on Page 19

PEM CORPORATION, DOYLESTOWN, PENNSYLVANIA

Los Angeles—Bradshaw 2-8097
Miami—Tuxedo 5-3147
Dallas—Fleetwood 7-5713

Typical steam forging hammer

REQUIRED SAFETY FACTORS in steering arm assured by designing it to be forged



By designing with forgings, a truck manufacturer can count on the required safety factors, with minimum "beefing-up" of parts to offset unknown internal structures or non-homogenious materials.

You, too, can achieve results like these by designing *with forgings* either at the start or on re-design. The benefits of forgings are equally impressive, whether you make home-workshop equipment or diesel engines.

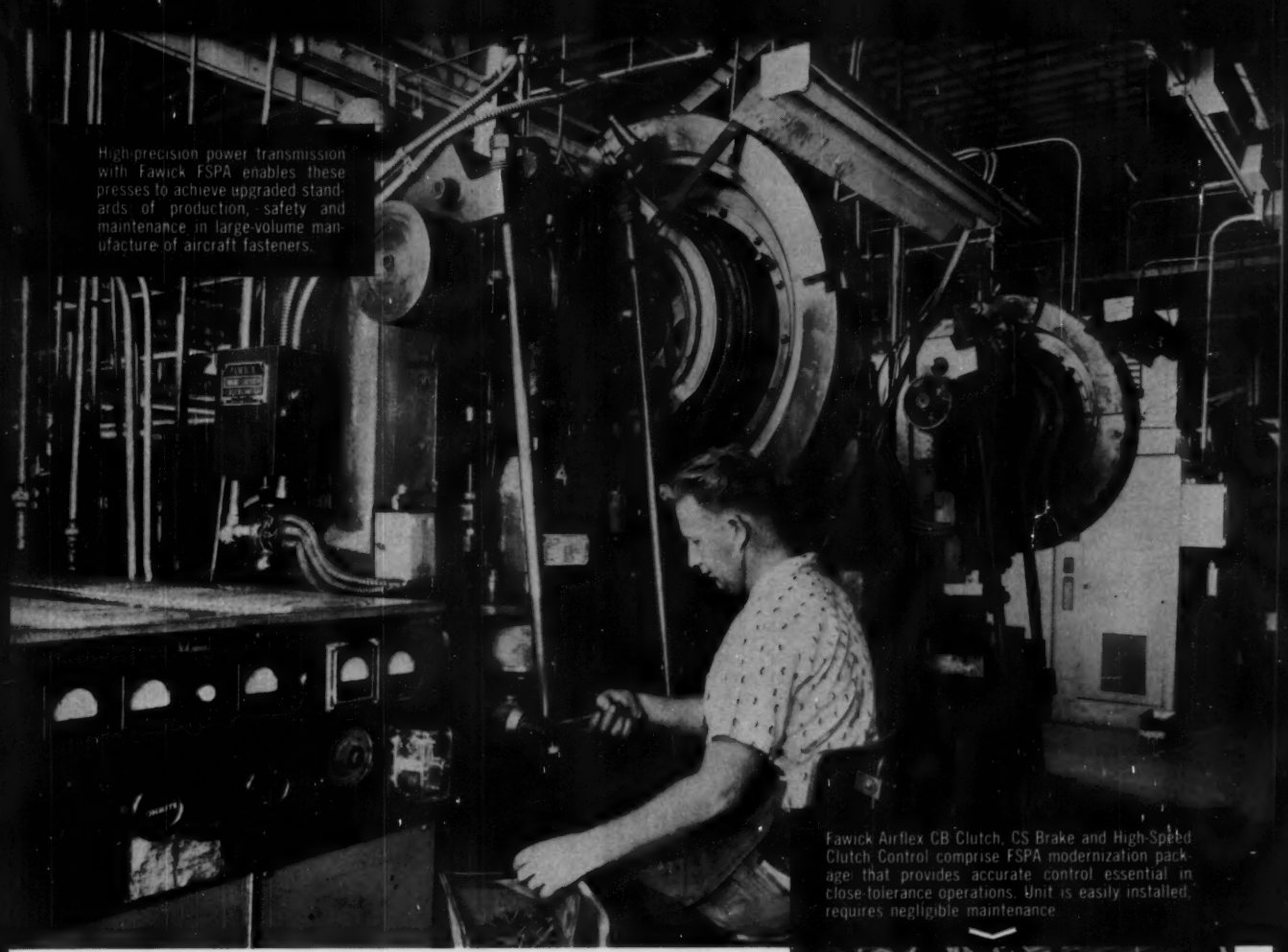
Forgings start as *better* metal . . . are further *improved* by the hammer-blows or high pressure of the forging process.

Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

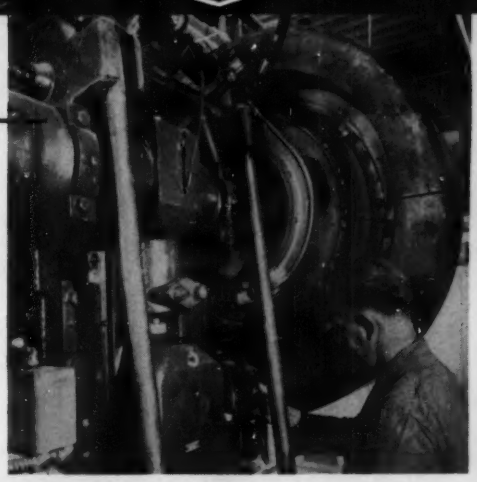


High-precision power transmission with Fawick FSPA enables these presses to achieve upgraded standards of production, safety and maintenance in large-volume manufacture of aircraft fasteners.

Fawick Airflex CB Clutch, CS Brake and High-Speed Clutch Control comprise FSPA modernization package that provides accurate control essential in close-tolerance operations. Unit is easily installed, requires negligible maintenance.

FSPA (*Fawick Standardized Press Application*)

eliminates backlash, reduces tool and die wear!



FAWICK FSPA provides a valuable built-in operating advantage on cyclic machines by eliminating damaging backlash. This increases die life and machine precision—resulting in increased production and greatly reduced tool and die maintenance costs.

This has been "proved-by-performance" at Voi-Shan Manufacturing Company, Culver City, California, where high-precision fasteners for aircraft and missiles are produced by the million with FAWICK-equipped hot heading punch presses. Since modernizing their equipment with FAWICK Airflex Clutches and Brakes, Voi-Shan has increased machine productivity 20% while cutting maintenance costs 80%.

High efficiency performance of FAWICK air clutches and brakes has provided Voi-Shan with other important advantages over former mechanical clutches: Push-button power transmission with FSPA eliminates emphasis on manual skill. Set ups are easy, exact, and cycle timing is extremely precise. Close tolerances are easily maintained throughout long or short production runs.

This application is just one example how production profit dollars may be increased by putting your power transmission problems in FAWICK's capable hands. Call your nearest FAWICK representative or contact the Home Office, Cleveland, Ohio.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX
INDUSTRIAL CLUTCHES AND BRAKES

Circle 487 on Page 19

See our booths 1136 and 1138 at the Design Engineering Show

. . . performance beyond the usual . . .

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
- **Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction**
- **Crowned rollers**
- **Modification of any factor to meet your application**

ROLLWAY

MAXIMUM

BEARINGS

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.

ENGINEERING OFFICES

Syracuse • Boston • Chicago
Detroit • Pittsburgh • Seattle
Cleveland • San Francisco
Houston • Los Angeles
Philadelphia • Toronto

Circle 488 on Page 19

BARBER-GREENE specifies INTERNATIONAL Power

for world's leading line of asphalt plants!

Report from Guy Banister,
Chief Technical Engineer,
Barber-Greene Co., Aurora, Ill.

"We standardized on International diesels for Barber-Greene Continuous Mix Asphalt Plants in 1947, and owners' reports prove we made an excellent choice."

"For 30 years Barber-Greene Continuous Plants have played a major role in making asphalt paving the world's most used road surface. Since the 30's road builders have been able to produce a controlled high-quality mix in high volume at low cost, and that calls for *efficient power.*

"Because the whole paving operation depends on our plants for asphalt production, plant downtime can run as high as $5,000 hourly. And since engines on the plants operate under continuous load 8 to 10 hours daily—that calls for *dependable power.*

"Since Barber-Greene Continuous Mix Plants are highly mobile—often moving to 6 or 8 jobs in a season—that calls for engines supported by an *excellent parts and service organization.*

"International diesel engines meet Barber-Greene standards for efficiency, dependability, and parts and service support. That's why we standardized on IH power for these plants. Performance records over the past 13 years show that our customers, too, are satisfied International users."

You, too, can build into your products the advantages of International power. Check the complete International engine line—32 carbureted and diesel models from 16.8 to 385 max. hp. You'll like the one common feature of all 32 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL®
IH ENGINES

International Harvester Co.,
180 North Michigan Ave.,
Chicago 1, Illinois
A COMPLETE POWER PACKAGE

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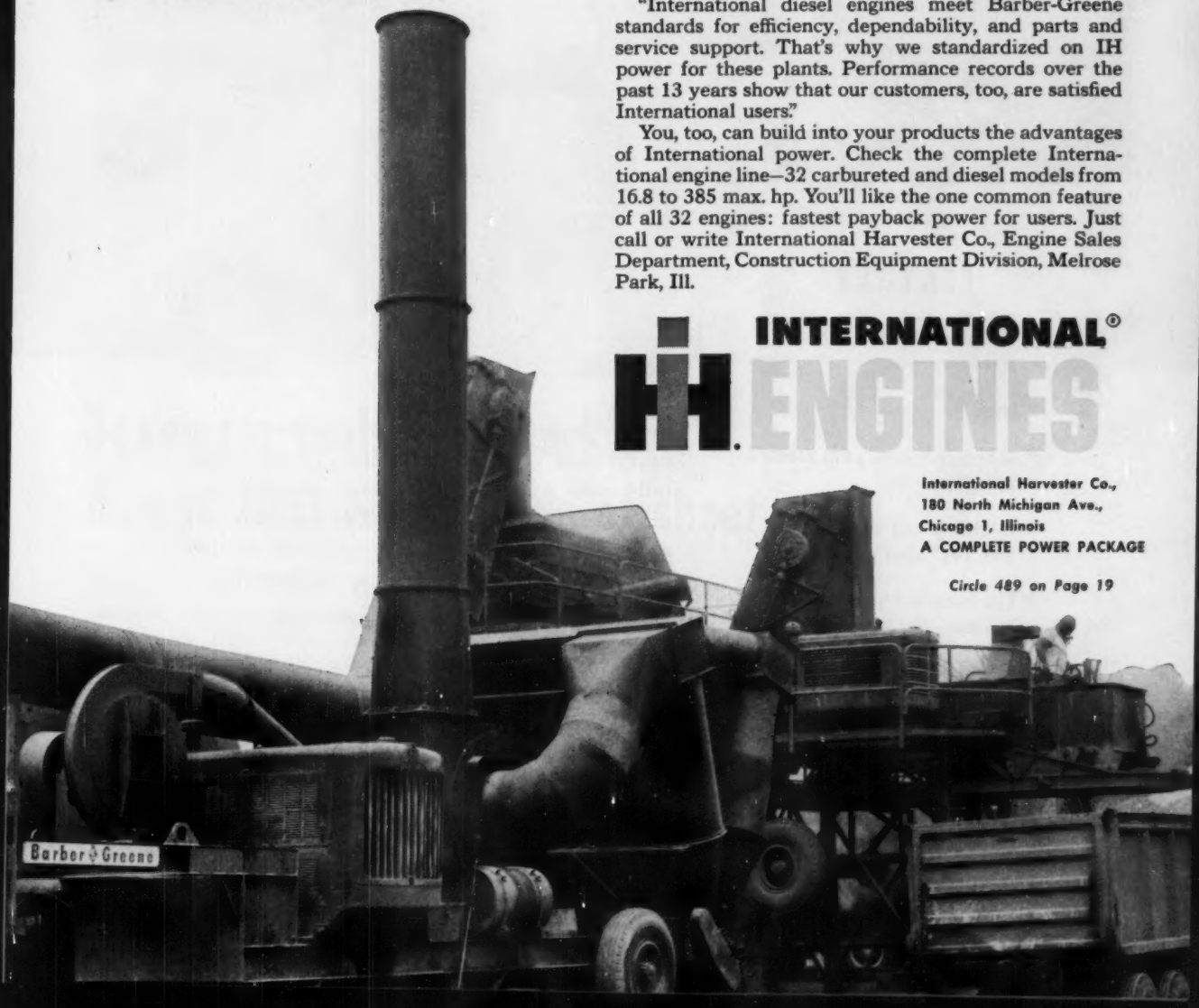
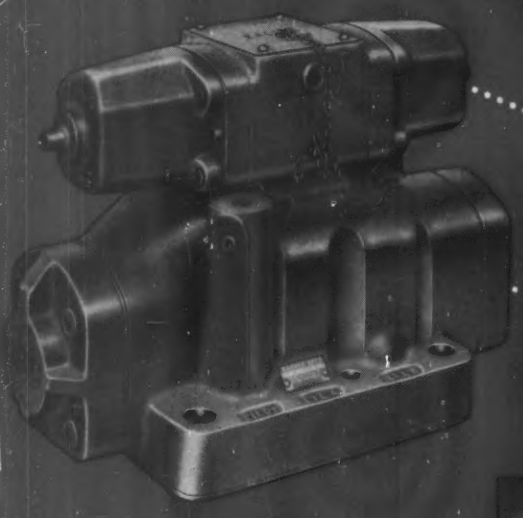


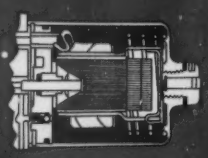
RACINE-SECO

VERSATILE

4-WAY HYDRAULIC DIRECTIONAL CONTROLS



NEW 1¼" VALVE ILLUSTRATED



OIL IMMERSED SOLENOIDS — Solenoids are available with oil filled cavity for better heat transfer, lubrication and cushioning of moving parts, thus contributing to longer valve life.

THROTTLING END CAPS—End caps are available with pilot choke adjustments for controlling speed of valve spool independently in all directions of movement. This includes independent control of all spring return and spring centering actions, with time delay up to 5 seconds.

FEATURES

- Design conforms to J.I.C. standards
- High flow capacity
- Direct or remote pilot pressure operation
- Throttling end caps for ¾" and 1¼" sizes
- Oil immersed solenoids available
- Sub-plate mountings on all sizes

From a design and operational consideration these RACINE-SECO valves are the finest directional controls made. Compact streamlined design — dust proof construction. RACINE-SECO 4-way valves are available in single solenoid spring return and double solenoid standard action or spring centering.

Sizes ¼", ¾" and 1¼" up to 2000 psi.

Write for RACINE-SECO Catalog No. 59-A describing our complete line of Hydraulic Equipment.

RACINE HYDRAULICS & MACHINERY, INC.
RACINE, WISCONSIN

One Source — One Responsibility for all your hydraulic needs.

Boxes for tools...or tackle they're best when made of sheet steel

Strong, durable, easy to work, light in weight, low in cost—all these factors point to sheet steel as the ideal material for tackle and tool boxes. Whether you make or use such boxes, you can be sure they're best if they're made of sheet steel.

Bethlehem sheets—cold-rolled as well as Bethcon continuously galvanized—are used in the manufacture of thousands and thousands of utility boxes. Other Bethlehem sheets go into automobile stampings, agricultural machinery, grain storage bins, metal furniture, tubing and, yes, baby carriages! We'll be glad to discuss your requirements.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Steel for Strength . . . Economy . . . Eye-Appeal

BETHLEHEM STEEL

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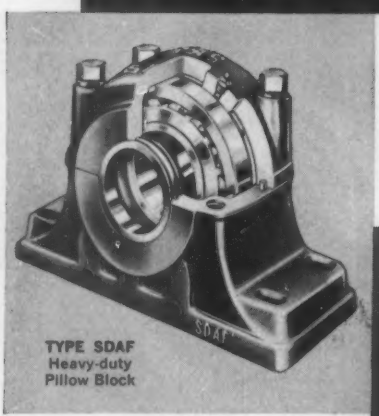
BETHLEHEM STEEL

TYPE SAF
Ball or Spherical Roller
Bearing Pillow Block

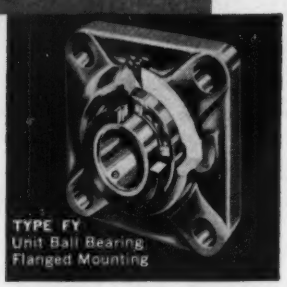
Can you get these "special" qualities in "standard" pillow blocks?



TYPE SDAF
Heavy-duty
Pillow Block

TYPE SY
Unit Ball Bearing
Pillow Block

TYPE SES
Unit Rubber-flex Ball
Bearing Pillow Block



TYPE FY
Unit Ball Bearing
Flanged Mounting

Most pillow blocks offer easy assembly and rugged housings. But can they offer you low friction, self-aligning bearing operation and efficient sealing as well?

They can—if they're the SKF pillow blocks, and flanged mounting, shown here. Type SAF, for example, comes equipped with low-friction ball or spherical roller bearings that are *inherently* self aligning. And these bearings are effectively protected by Triple-Seal rotating rings. Abrasives and corrosives can't get to them—oil or grease can't drip out.

Yet this is a standard SKF pillow block, that is competitively priced in spite of its combination of extra features. We make it for shaft sizes from ¾" to 10½", for mounting directly or with an adapter. A cast steel housing (SAFS) is available for heavy duty applications.

For details, call one of our twenty-four offices. 5938

Spherical, Cylindrical, Ball, "Tyson" Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U.S. PAT. OFF.

For Your Power Drive • Design • Application or Replacement Maintenance

There's a T-J CYLINDER

That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application—with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

Plus

THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.

SQ-1058-4 for the T-J Squair Head cylinder.

No. 54 for standard tie-rod air cylinders.

SM-56-3 for the incomparable Spacemaker cylinder.

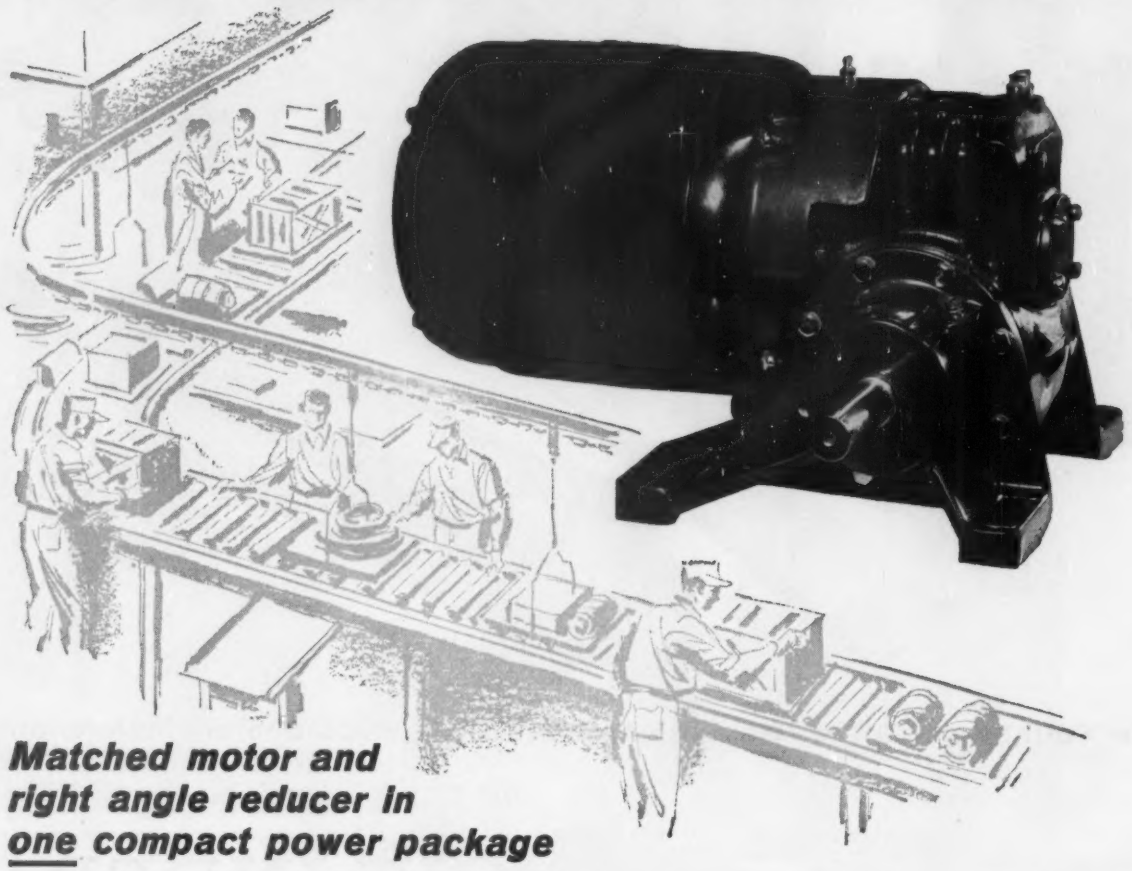
HSM5-58-4 for the High-Pressure Hydraulic Spacemaker cylinder.

THE TOMKINS • JOHNSON CO. JACKSON, MICH.

CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS Circle 493 on Page 19

MASTER GEARMOTORS

simplify applications—save space



Matched motor and right angle reducer in one compact power package

Reduction of engineering and assembly cost . . . elimination of separate components . . . are basic in this Master Right Angle Gearmotor. Consider these specific advantages:

1. No high speed coupling.
2. No V-belts or chains and sprockets.
3. Takes up less space—reduces mounting plates.
4. Special flange or face mounting can eliminate low speed coupling.
5. Saves aisle space . . . drives around the corner.
6. Wide acceptance by machine builder and user.

Master Gearmotors are built with ratings from ⅛ to 125 h.p. . . . in right angle, parallel or in combination. Right angle ratios are available to 96:1; parallel 120:1.

Electrical and mechanical modifications give you a maximum choice—vertical, horizontal, and flange mountings; output shaft over, under, left or right. These gearmotors can be supplied with built-in accessories: a fluid coupling for hard-to-start loads or cycling loads; a brake for fast stops and positive holding.

Call your nearest Reliance Sales Engineer. Let him tell you why more Master Gearmotors are in use today than any other make. B-1643

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 284A, CLEVELAND 17, OHIO

Canadian Division: Toronto, Ontario

Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

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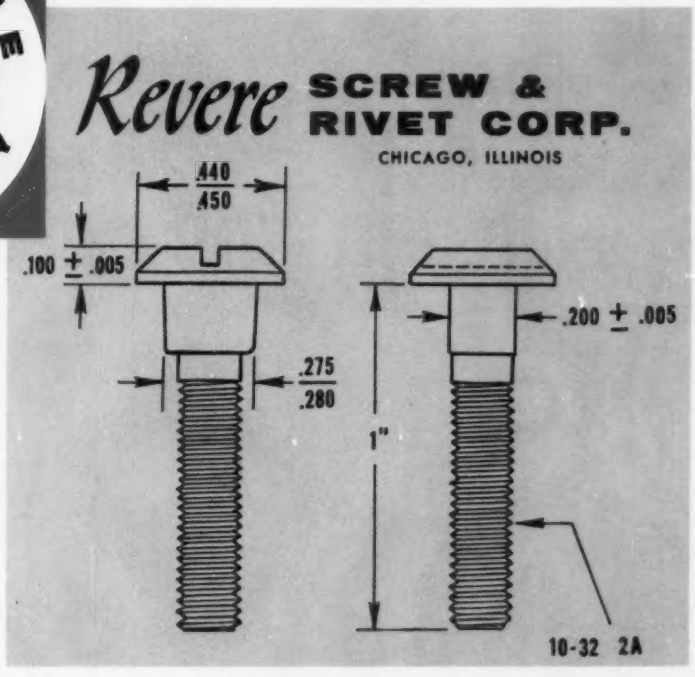
Circle 495 on Page 19→

KEYSTONE XL WIRE STUDY



ACTUAL SIZE

heading problems solved *with Keystone XL Wire*

The cold heading of this generator shoulder bolt required extreme flow of material in concentric shapes, two diameters to be struck in one blow. Specifications were a rigid .005 tolerance. Because of the *flowability* characteristics of Keystone "XL" Wire, Revere Screw & Rivet Corp. have been able to produce this complicated fastener at high production rates and economical costs.

Revere president, Sol Gross, credits the uniform size and quality of Keystone "XL" Wire for increasing production, waste elimination and long die life. In fact, a three-fold increase in die life was realized.

Your cold heading problems can be simplified and solved when you put the *flowability* characteristic of Keystone "XL" Wire through your dies. Ask our Keystone wire specialists for complete information.

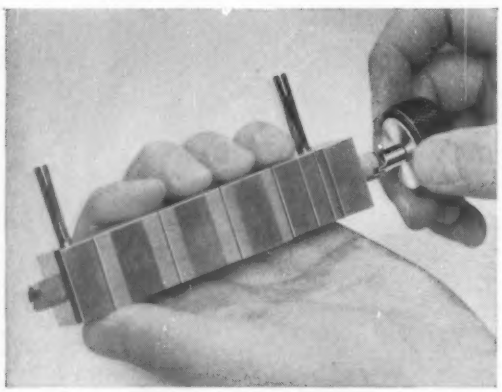
Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE WIRE FOR INDUSTRY

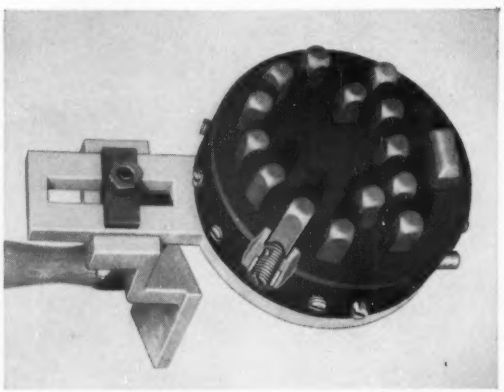
Practical Design Tips

No. 5 of a series

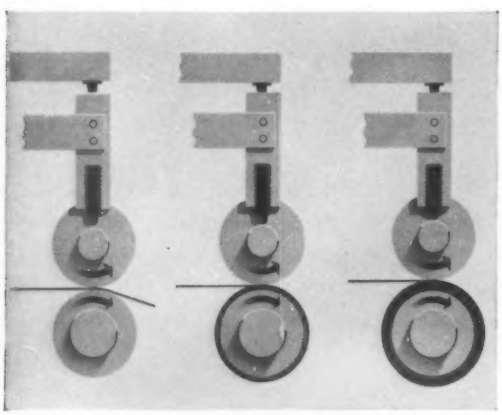
Cost conscious product designers are finding new uses for Vlier products in all types of original equipment. Simple applications such as shown below are saving hundreds of dollars. Examine your drawings and products today and see where these inexpensive, off-the-shelf parts can lower your costs.



TORQUE APPLIED TO ASSEMBLE PRECISION GAGE BLOCKS is limited by this modified Vlier Torque Thumb Screw. Ground screw point mates with assembly screw; prevents overtightening with resultant damage to blocks. Torque Screws are available in four types, many thread sizes, lengths and end pressures.



SPRING-LOADED BALL PLUNGERS HOLD MARKING STAMPS IN POSITION, yet allow them to move freely when struck. Ball Plungers are threaded into metal inserts molded in rubber. Binding action of rubber prevents plungers backing off. Plungers come in six models; sizes from #4-48x3/16. to #5/8-11x1; 18 end pressures.



LIMIT SWITCHES ON THIS TEXTILE DRAWING FRAME ARE PROTECTED by Vlier Spring Plungers. Bunching of broken threads causes rolls to lift, actuating limit switches which automatically shut off the machine. Plungers permit normal operation of the switches, but limit over-travel of switch actuating arm. Spring Plungers are available in four models, 50 sizes, various end pressures.

FREE IDEA BOOKLET! This informative 16-page booklet shows how other original equipment manufacturers are profiting from the use of standard Vlier parts. It may suggest ways you can save, so write for your copy today.

VLIER
Engineering Corporation
Subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California

LINK-BELT P.I.V. is available in all these ways for

super-sensitive quality control

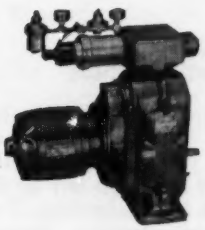
Here's the basic P.I.V. for stepless, slipless speed changing

Today a growing number of production machines and operations demand extremely accurate transmission of power with variable speed control. For these requirements, Link-Belt P.I.V. is available in the many ways shown below—with automatic controls and integral differential to satisfy an infinite number of variable speed applications.

Variable from top speed to minimum speed with no steps, no stops in between, Link-Belt P.I.V. is industry's only chain-driven variable speed drive. Teeth—not tension—permit positive, high-efficiency power transmission.

For information on the full P.I.V. line, call your nearest Link-Belt office. Or write for Book 2274 on basic P.I.V., Book 2349 covering automatic controls and Book 2774 explaining P.I.V. with integral differential.

Link-Belt P.I.V. is available in 8 sizes and 16 standard types, in capacities from ½ to 25 hp—for horizontal or vertical mounting. Compact design simplifies installation as a separate unit or a built-in part of a machine. P.I.V. is totally enclosed, automatically lubricated.



PNEUMATIC (shown) — The P.I.V. pneumatic ratio changer is used as a final control element providing fully automatic control of speed. Operates from standard pneumatic controller in systems regulating pressure, temperature, rate of flow, etc.

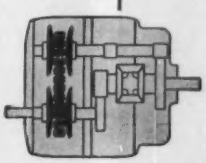
MECHANICAL — Predetermined timing, cyclic, or characterized regulation can be accomplished by P.I.V. with mechanical controls.

HYDRAULIC (shown) — Consists of a low-pressure hydraulic Servo system with a precision valve positioner. Intended to give automatic speed control by direct operation with any form of linkage. A minimum operating force is required.

ELECTRONIC — Flexible form of speed control to provide either "on-off" or modulated speed response of P.I.V. drive. Electric control motors are available to match a wide variety of electrical control systems.

P.I.V. with integral differential gearing

CONDENSED SPEED RANGE TYPE of integral differential results in a ratio range less than a standard P.I.V. with the advantage of increased horsepower capacity, high ratio stability and accuracy. These drives are applicable wherever small ratio range is required but with extreme accuracy of ratio control.

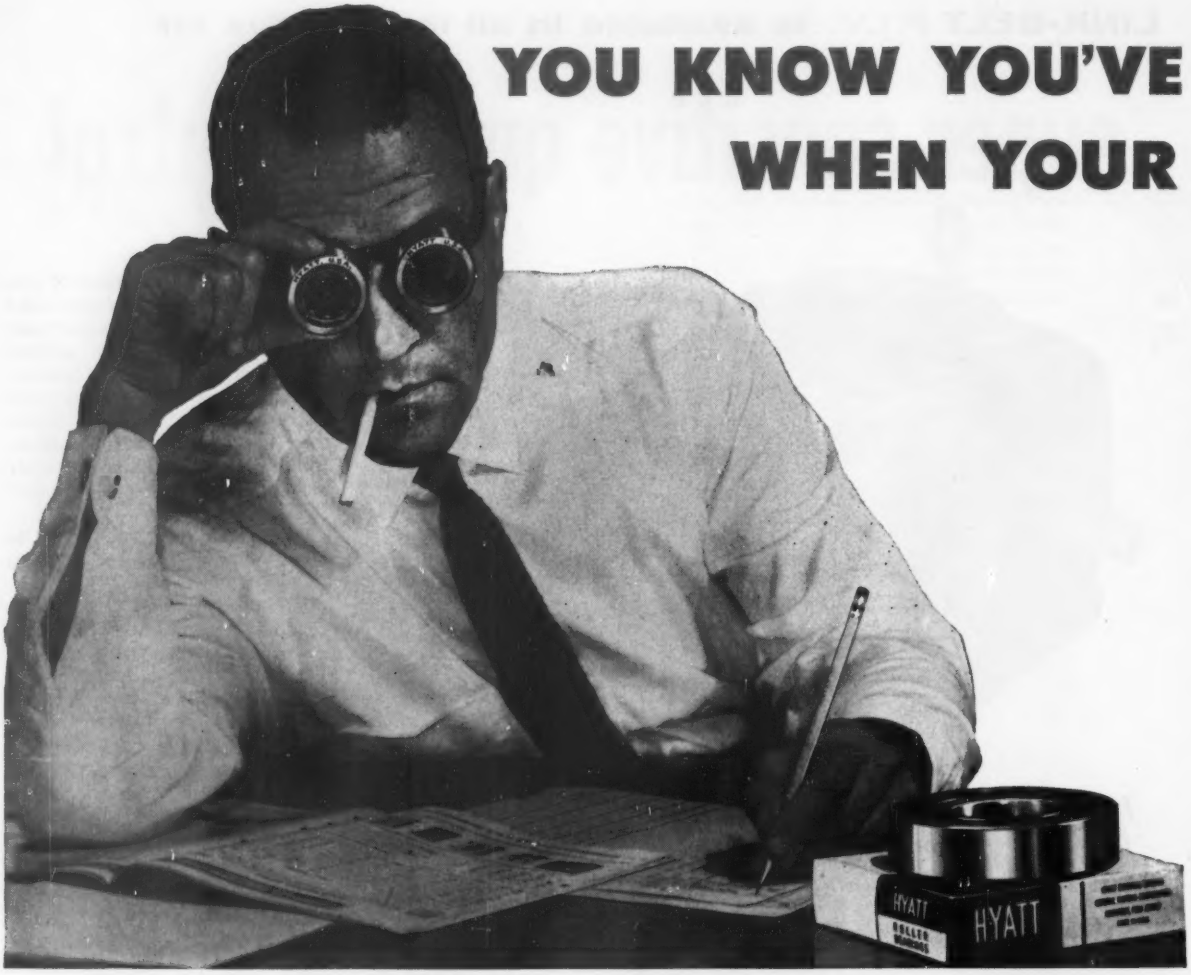


EXTENDED SPEED RANGE TYPE of integral differential results in infinite ratio range and output speeds down to zero with a constant input speed. Clockwise and counterclockwise rotation through zero is also obtainable. These drives may be used whenever a ratio range greater than 6 to 1 is required.

LINK-BELT P.I.V. VARIABLE SPEED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 18,103

YOU KNOW YOU'VE WHEN YOUR

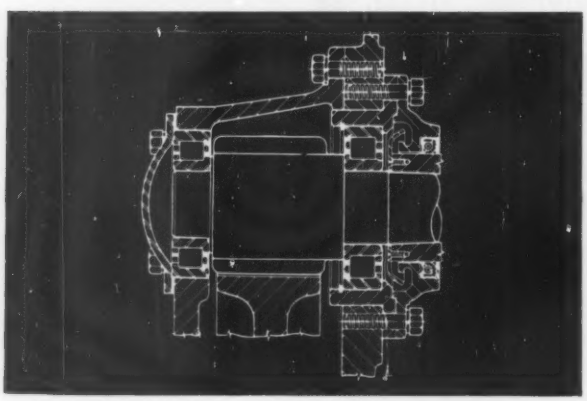


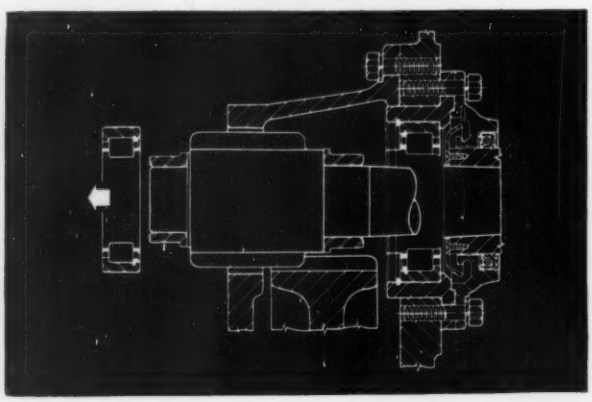
SIMPLIFY AND SAVE

A second look at the very same shaft shows how easy it is to "design in" a Hyatt bearing. It requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be affixed to the shaft with a heavy press fit. Rest assured, they'll never come loose because Hyatt Hy-Roll races are made from case-hardened, carburizing type steel. The hard outer case and tough ductile core permit heavier press fits without fear of cracking.

EXPEDITE ASSEMBLY

When a product is assembled, you can see why Hyatt makes all separable races interchangeable within the same part number. For it allows you to press the inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because Hyatt has made selective fitting unnecessary. Think of the time it saves!

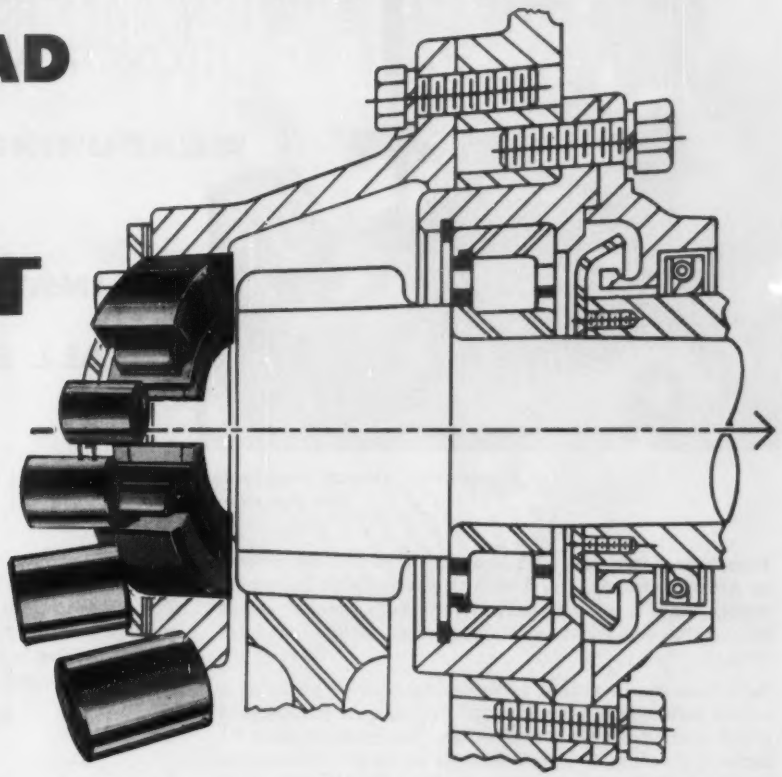




PUT THE SHAFT IN ITS PLACE

"SPECS" READ

HYATT



DO BOTH JOBS AT ONCE

Remember how versatile Hyatt Roller Bearings can be. Primarily, they're designed for the heaviest radial loads. But, with shouldered races, they'll also accommodate a considerable amount of thrust load . . . enough to provide adequate shaft location.

Here, for example, is a spur gear drive pinion on an opposed pair of R-YS type Hyatt Hy-Roll Bearings. Shoulders on the inner and outer races restrict lateral movement without sacrificing any of the high load carrying capacity inherent to cylindrical roller bearings. Thus, Hyatt gives you a bearing combination that combines high radial load carrying capacity with convenient shaft location.

You're assured smooth, trouble-free performance the minute you specify Hyatt Hy-Roll Bearings. For Hyatt quality is constantly checked and electronically controlled to insure that the last Hyatt Hy-Roll is every bit as accurate as the first.

Hyatt produces 10 major bearing types—four have separable inner races

—four non-separable

—and two have separable outer races.

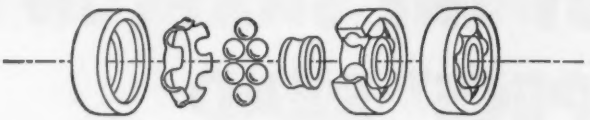
The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the shaft or housing bore can be suitably hardened and ground.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt Sales Engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY



MEASURING ROUNDNESS OF INSTRUMENT BALL BEARINGS

By **RICHARD E. AMIDON**, *Staff Engineer, Production Engineering Department*
New Hampshire Ball Bearings, Inc.

Roundness of instrument ball bearings is a variable not covered by ABEC standards. Yet, it is an important factor in running quality. Since it is a very difficult variable to measure, except with costly equipment, most users must accept roundness on faith.

Roundness can be defined as "equidistance of all points on a curved surface from a fixed center". To measure roundness of a ball bearing component, therefore, you must establish its center and radius. However, since its center is not accessible as a point of reference, you must establish an "artificial" center. The closer the assumed or artificial center is to the actual center, the more accurate a given method of roundness measurement will be.

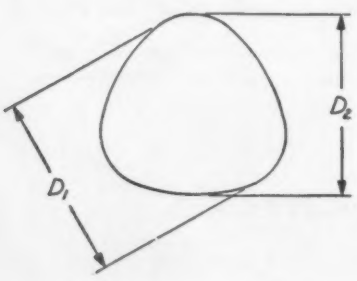
What you're really measuring is out-of-roundness, or deviation from a true circle. Such deviations are called lobing. There are three common ways of measuring out-of-roundness.

THE TWO-POINT METHOD

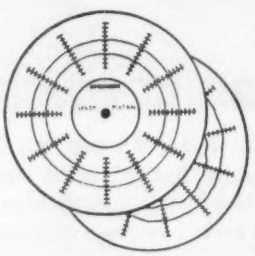
Most widely used of all measuring techniques is the method of measuring various diameters between two anvils as in a micrometer or two-point gage. The difference between the largest and smallest diameter is out-of-roundness. This method is accurate only if there is an even number of lobes of equal height and symmetrical spacing. Notice in the accompanying sketch of a three-lobed shape, all three diameters are equal . . . and the two-point method would indicate perfect roundness.

THE THREE-POINT METHOD

When an odd number of lobes exists, a three-point gage can be used to measure out-of-roundness. Variations are measured by rotating the part between two fixed points at a known angle with each other and a movable point connected to an indicator. This method, which calls for calculations to convert indicator readings to true-out-of-roundness, is accurate only when the number of lobes is known and they are symmetrically spaced and equal in height.



ELECTRONIC GAGING



POLAR CHART TRACE

Fortunately for you, instrumentation has been recently developed which measures out-of-roundness directly as radial variation with accuracy to several millionths of an inch. The part to be measured is chuck-mounted to a precision spindle and slowly rotated. An electronic gage head translates radial surface variations into a polar chart trace with deviations magnified as much as 10,000 times. Comparison of the chart trace with concentric circles of known radii reveals absolute deviation from a true circle. New Hampshire Ball Bearings, Inc. was the first to use this instrument as a quality control tool in the laboratory and on the production line. Other instrumentation used to assure the running quality of New Hampshire Bearings is described in our new Design and Purchasing Manual.

NEW DESIGN MANUAL

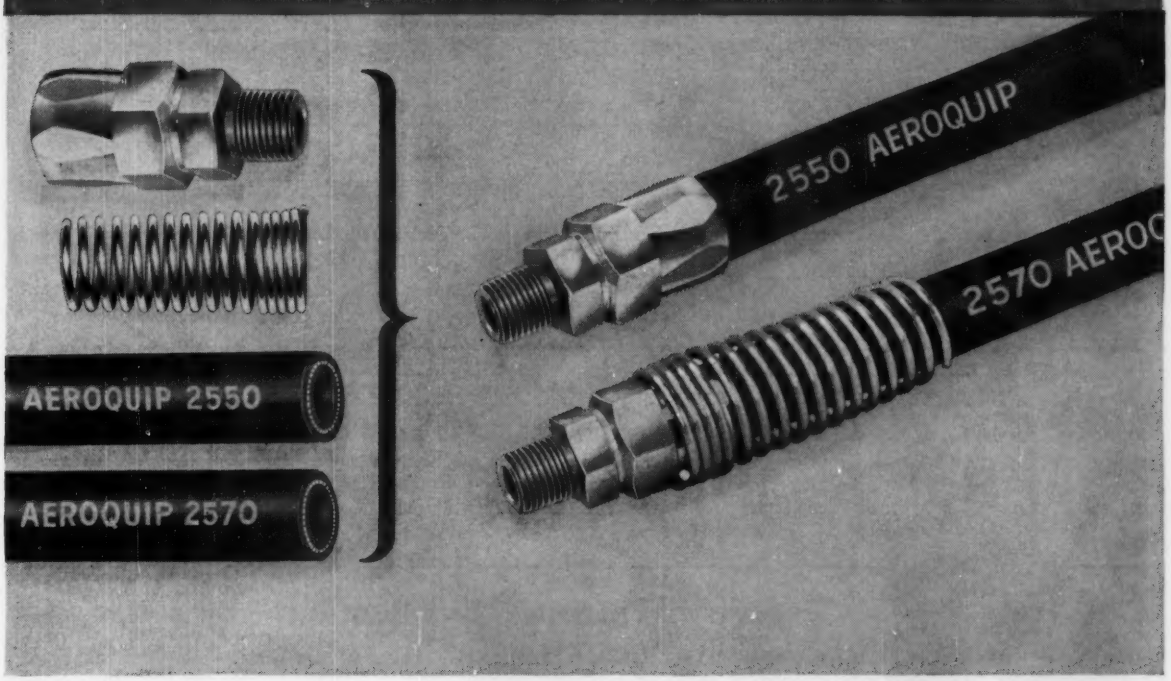
Newly revised and expanded, this authoritative publication covers everything you need to know about applying and buying miniature and instrument ball bearings. Comprehensive general information, catalog data and engineering bulletins are included in its 100-plus pages. Personally registered copies are available to qualified engineers, draftsmen and purchasing agents. Please send your request on your company letterhead.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

Circle 499 on Page 19

Use This New Aeroquip Fitting With S.A.E. Type A or Type B Air Brake Hose

. . . WITH OR WITHOUT SPRING GUARD!



Aeroquip simplifies purchasing and inventory of air brake hose components for equipment manufacturers. Just one type of fitting need be stocked for S.A.E. Type A or Type B air brake hose and can be used with or without spring guards. All air brake lines are assembled from these parts.

Equipment operators can reduce maintenance costs, too. The fitting is detachable and may be used over and over as replacement lines are needed.

Aeroquip Hose and Fitting combinations are approved by the Pennsylvania Bureau of Highway Safety. Both Aeroquip 2550 (Type A) and 2570 (Type B) hose are made to S.A.E. Specification 40R2.

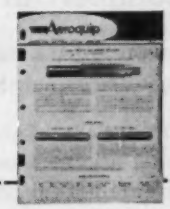
HOSE SPECIFICATIONS

Hose Type	O.D. Tube Size	Min. Burst PSI	Operating PSI	Min. Bend Radius
2550-6	⅜	900	225	1¾
2570-6	⅜	900	225	1¾
*2554-6	⅜	900	225	1¾

*Aeroquip 2554-6 Low Temperature (—65° F.) Hose conforming to Ordnance Specification MIL-H-3992A, Type I, Class 1.

ALL DIMENSIONS IN INCHES

Aeroquip provides complete engineering assistance to equipment manufacturers. Write for Bulletin IEB-38.



SEE AEROQUIP DISPLAY, BOOTH 847, A.S.T.M.E. SHOW, DETROIT, APRIL 21-28

Aeroquip®

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA

AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Aeroquip Corporation, Jackson, Michigan MD-4

Please send me your bulletin IEB-38 covering your new reusable fittings and air brake hose.

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Name your load and speed combinations

We'll fit these bearings—or special types and sizes to your special needs.
Just fill in your application problem below—attach to your letterhead and mail.

THE SCHATZ MANUFACTURING COMPANY, Poughkeepsie, N. Y.
Here's our bearing problem. What do you suggest?

APPLICATION_____

LOAD (radial, thrust or both)_____

SIZE_____

SPEED_____

LIFE FACTOR_____

OPERATING CONDITIONS_____

SPECIAL CONDITIONS_____

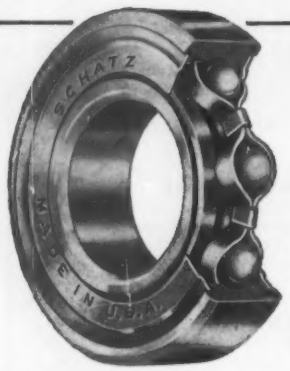
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Schatz makes the most varied line of Ball Bearings to fit your needs



"Functional Precision" Ball Bearings—BR series

One piece race type with ball cage. Designed to give all the precision you require under certain ratios of load, speed and life expectancy. Available in open type, single or double shielded, single or double sealed with Schatz patented low friction plastic seal. Or with one shield and one seal on special order.

23 sizes from 3/16" to 1"—6 types in each size + specials

"Commercial" Ball Bearings—The most complete and varied line anywhere.

UNGROUND BALL BEARINGS "TYPE A"—Every standard type—radial, thrust and radial thrust.

GROUND BALL BEARINGS "TYPE B"—Used and recommended where greater accuracy and smoother running qualities are needed and where loads are heavier and speeds higher.

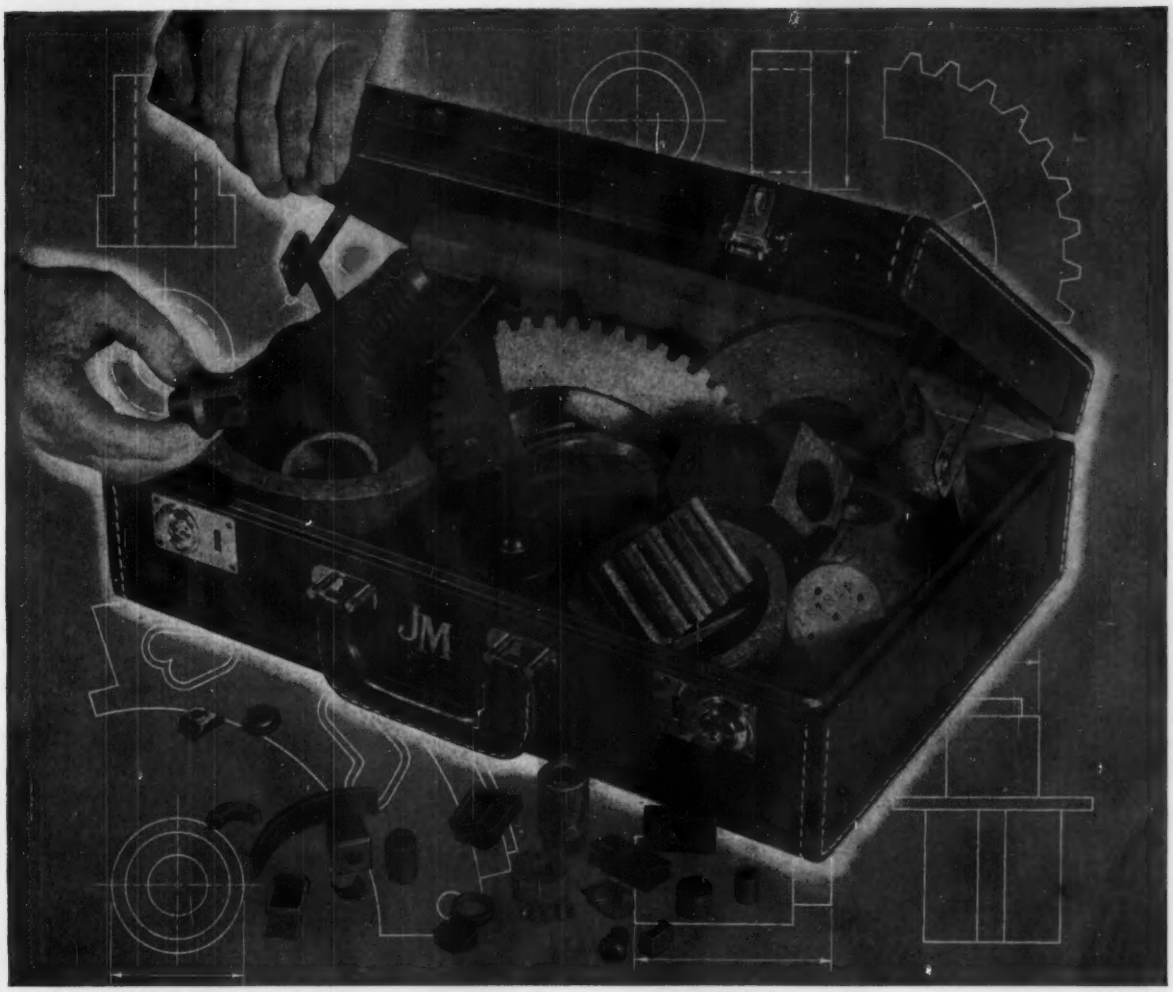
1033 sizes to match your Bearing Application Needs

SCHATZ
BALL BEARINGS

• *See our Catalog in SWEET'S*

THE SCHATZ MANUFACTURING COMPANY • Poughkeepsie, New York

When it's time to pick the best friction materials for your latest clutch or brake design



The J-M Friction Specialist is a good man to have at your side!

No one friction material can possibly handle all motion control needs. That explains the wide latitude the J-M product line offers you when it's time to select frictions to suit *your* design.

Johns-Manville has developed a range of frictions to meet almost any requirement. Each piece can be depended on to give the sort of performance expected in well-designed equipment. And experienced J-M Representatives and extensive J-M research facilities are ready to help you select the most effective and economical material. Where miniaturization is a factor . . . in wet or dry operations . . . J-M Frictions can be ordered as small, integrally molded precision parts. J-M Small Molded Parts can also be compounded for anti-friction needs such as rotary seals, bushings or bearings. Now—before you get to work on that new design—is a good time to consult your J-M Friction Specialist.

For your free copy of the J-M Industrial Friction Materials Guide, giving recommendations, design and operational data on all J-M friction types and styles, write Johns-Manville, Box 14, New York 16, N.Y. In Canada: Port Credit, Ontario. Ask for FM-35A.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Circle 502 on Page 19

IF CUSTOM PARTS ARE YOUR PROBLEM

Sylvania can solve it with complete QC* service

Helps you with completely objective recommendations for your parts. Sylvania is backed by long experience in metals, plastics, welds and assemblies, can produce parts utilizing a wide range of equipment.

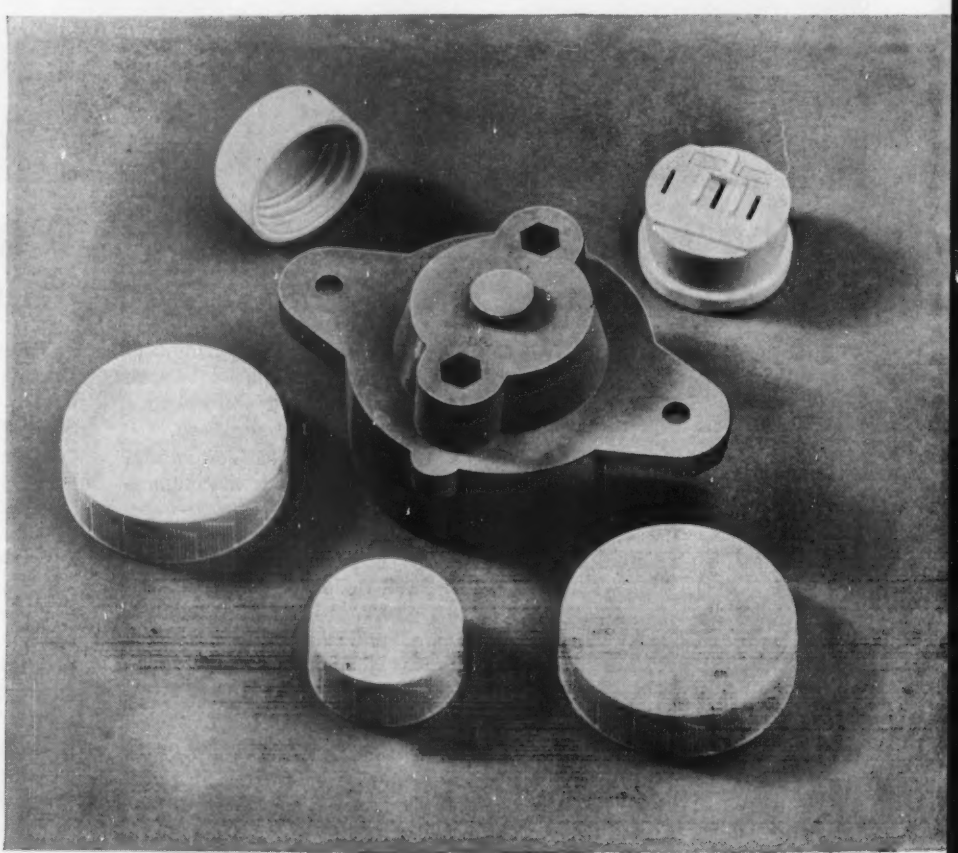
Offers design assistance that can often improve the quality of your part, lower production costs.

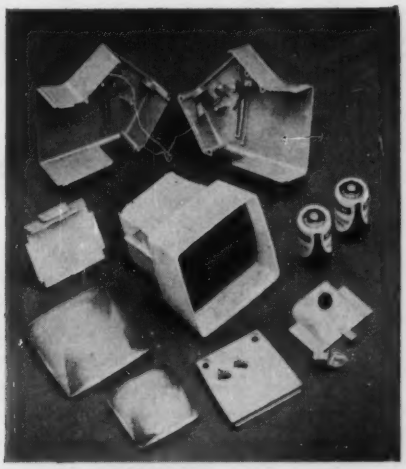
Provides superior quality parts. Sylvania utilizes the most modern equipment available, and its experience in tooling means better quality at lower costs for finished parts. In addition, Sylvania practices preventive maintenance for dies and equipment to assure you precise uniformity and uninterrupted production.

MOLDED FROM PLASTIC

Sylvania offers "total" low piece prices. Reason? It operates probably one of the most complete lines of modern automatic molding equipment in the world for compression, injection and transfer molding. Its bank of rotary presses can produce more than a million parts a day, is ideally suited to phenolics and urea, and assures minimum cost for simply designed plastic parts.

Results: your plastic parts —in volume—are produced quickly and at low cost.

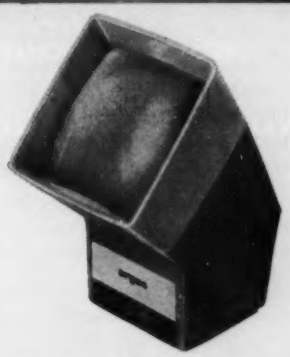


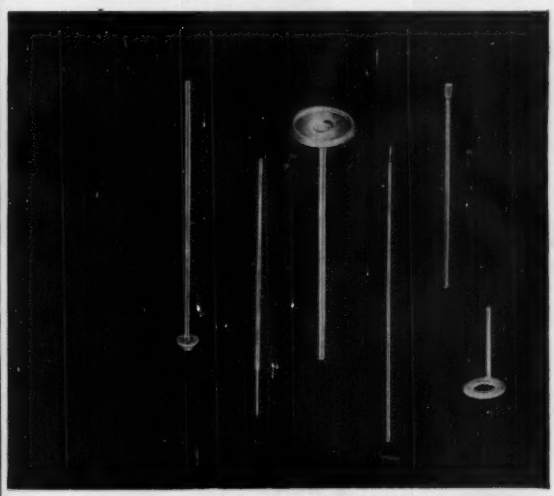


FORMED FROM METAL

Sylvania maintains custom metal stamping facilities, can produce millions of precision-made parts each day from all types of metal. The scope and flexibility of these facilities mean that it can deep-draw eyelets, shells, cups and ferrules. What's more, a battery of multi-slide machines can produce more than 2 million parts daily. Vertical presses can meet daily production needs of 2 million parts. And special, Sylvania-developed machines can produce great quantities of small wire and ribbon forms as well as wire cuts and leads.

Results: Sylvania can supply the parts you need—in high production quantities—of top quality—and at lower cost.





CUSTOM WELDED

If your part is standard-sized, miniature or subminiature, welded assembly is a Sylvania specialty. To help meet your custom assembly needs, Sylvania has developed new high-speed, high-volume welding techniques, advanced welding equipment, automatic and semi-automatic, and a corps of trained specialists.

Result: Sylvania welded assemblies assure high-quality electrical and mechanical contact, mirror-image uniformity, low cost.

CUSTOM ASSEMBLED

Many of our customers have analyzed their parts assembly needs. And they have discovered that Sylvania can often deliver a completely assembled and packaged product—using either all Sylvania components, all customer components or both—at lower cost than is possible within the customer's own facilities.

Result: If your product is small, the parts predominantly plastic and metal, and the quantities 50,000 or more, it pays to have Sylvania assemble it.

*QC MEANS QUALITY CONTROL!

Sylvania maintains a complete quality control department to assure that parts are made to your exact specifications. This control works for you throughout the manufacturing cycle. It's just one more way you benefit when you have Sylvania on the job.

For full details or a quote, write Sylvania Electric Products Inc., Parts Division, Warren, Pa.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

Circle 503 on Page 19

300 HOUSINGS PER HOUR

produced on Greenlee machine— with assist from VICKERS *hydraulics*

Here's a Greenlee transfer machine that produces 300 steering gear housings per hour while performing a total of 114 close tolerance machining operations. This outstanding performance record is achieved because the machine combines advanced design ideas with the best available components.

Self-contained Vickers hydraulic power packages provide controlled power for clamping the pallet-mounted workpieces in precise position at each work station, driving transfer mechanisms and for movement of certain machine heads. These power packages are designed to JIC (Joint Industry Conference) standards which means easy maintenance and minimum downtime to you.

Vickers offers you power packages, either standard or custom engineered that provide an almost unlimited number of choices to meet your specific technical requirements. You can choose from the broadest product line in the industry any combination of controls for use with single, double, two-pressure or two-stage pumps (the latter for pressures to 2000 psi), and for variable and constant delivery pumps to 5000 psi. Your choice of components will be packaged with the size or shape reservoir best suited for your job.

Whether the Vickers power package you choose is standard or custom engineered, you save money and time because it comes *ready-to-go*—designed and assembled to the highest standard of quality by hydraulic specialists.

Get more data by writing today for Bulletin 5001C or by consulting your nearby Vickers application engineer.

VICKERS INCORPORATED 8514

DIVISION OF SPERRY RAND CORPORATION

Machinery Hydraulics Division

ADMINISTRATIVE and ENGINEERING CENTER

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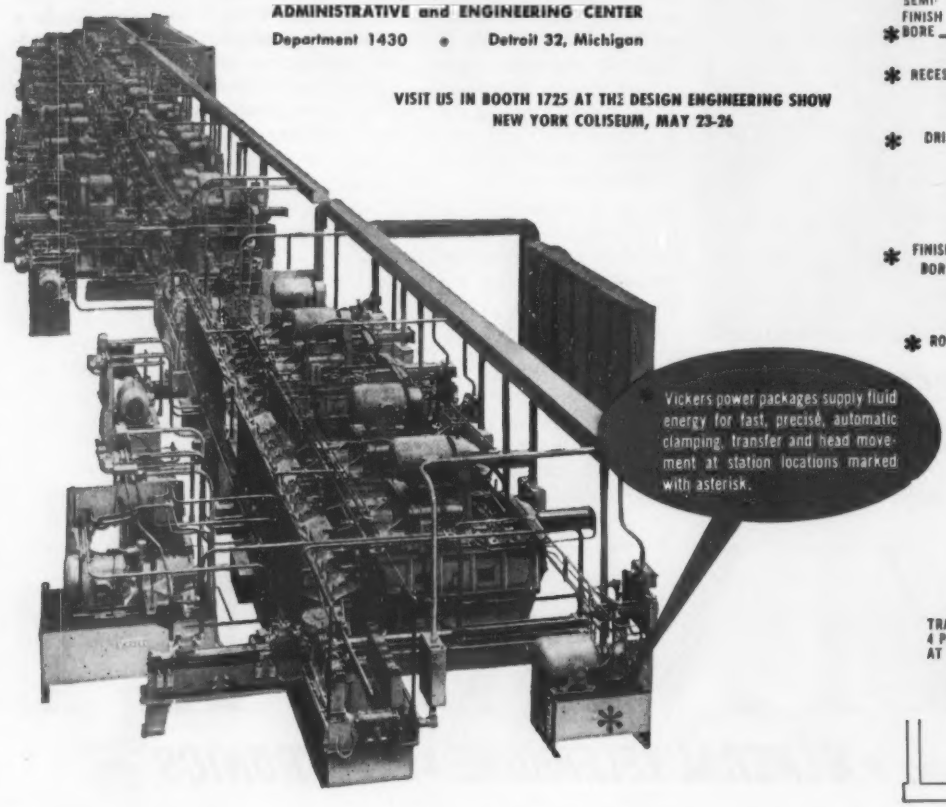
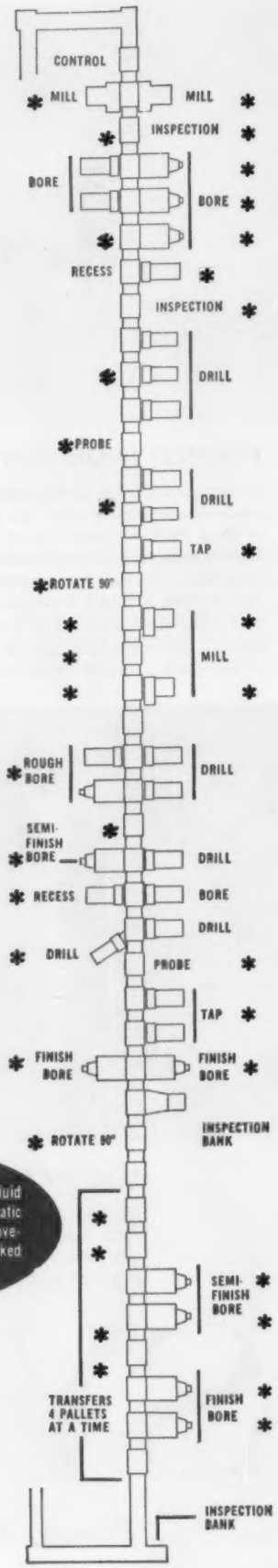
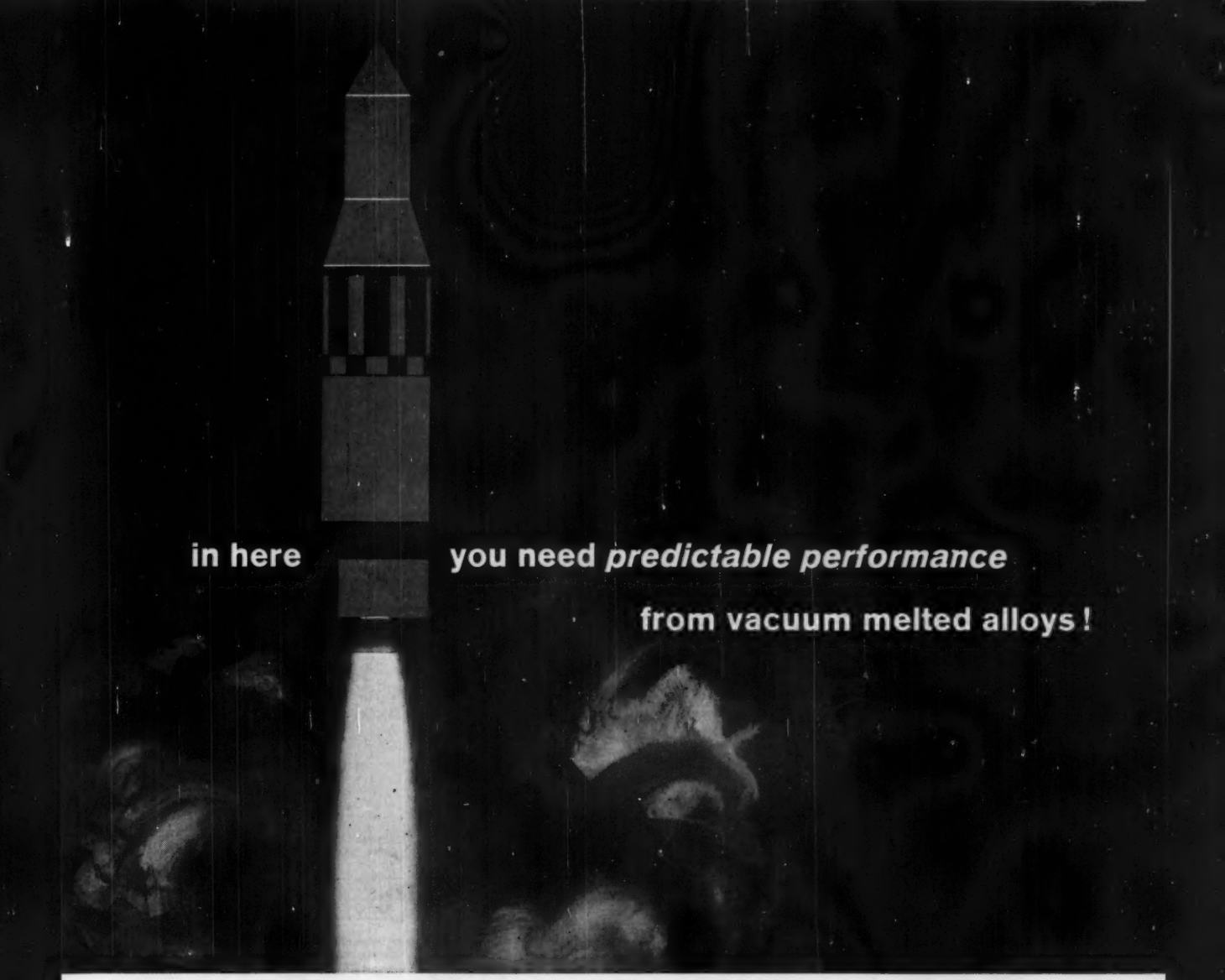


Vickers power packages supply fluid energy for fast, precise, automatic clamping, transfer and head movement at station locations marked with asterisk.





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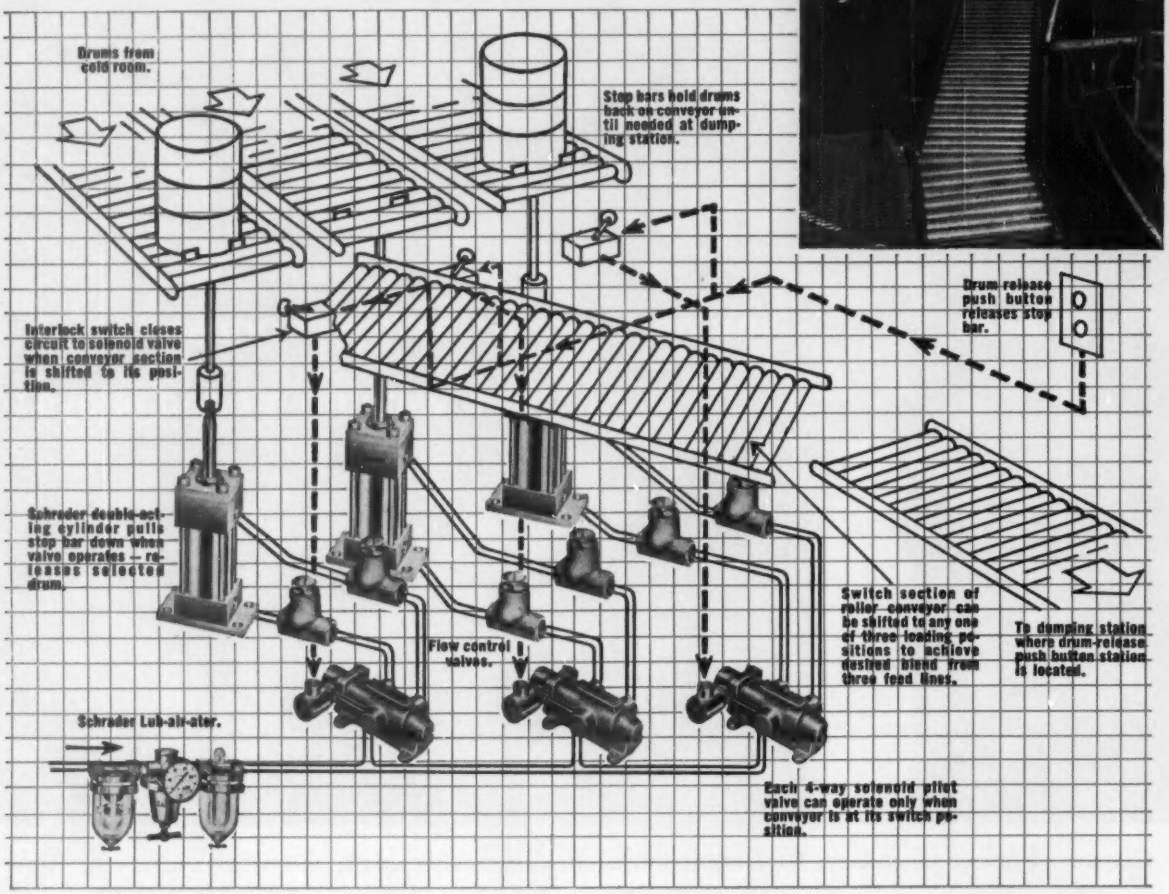
Circle 505 on Page 19

Processors automate even heavy work with air. In a complex frozen juice concentrate blending operation, Plymouth Citrus Products Cooperative, Plymouth, Fla., hooks up Schrader Air Products simply and economically to a gravity conveyor. Full 55-gal. barrels on feed sections roll down to stop bars and are selected in correct order and ratio for dumping. "The Schrader system performs well," says C. Byron Smith, plant manager. "We're handling 200 to 300 barrels a day on this selective conveyer, and could handle more."


Drums from cold room.
Stop bars hold drums back on conveyor until needed at dumping station.
Drum release push button releases stop bar.
Interlock switch closes circuit to solenoid valve when conveyor section is shifted to its position.
Schrader double-acting cylinder pulls stop bar down when valve operates -- releases selected drum.
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Switch section of roller conveyor can be shifted to any one of three loading positions to achieve desired blend from three feed lines.
To dumping station where drum-release push button station is located.
Schrader Lub-air-ator.
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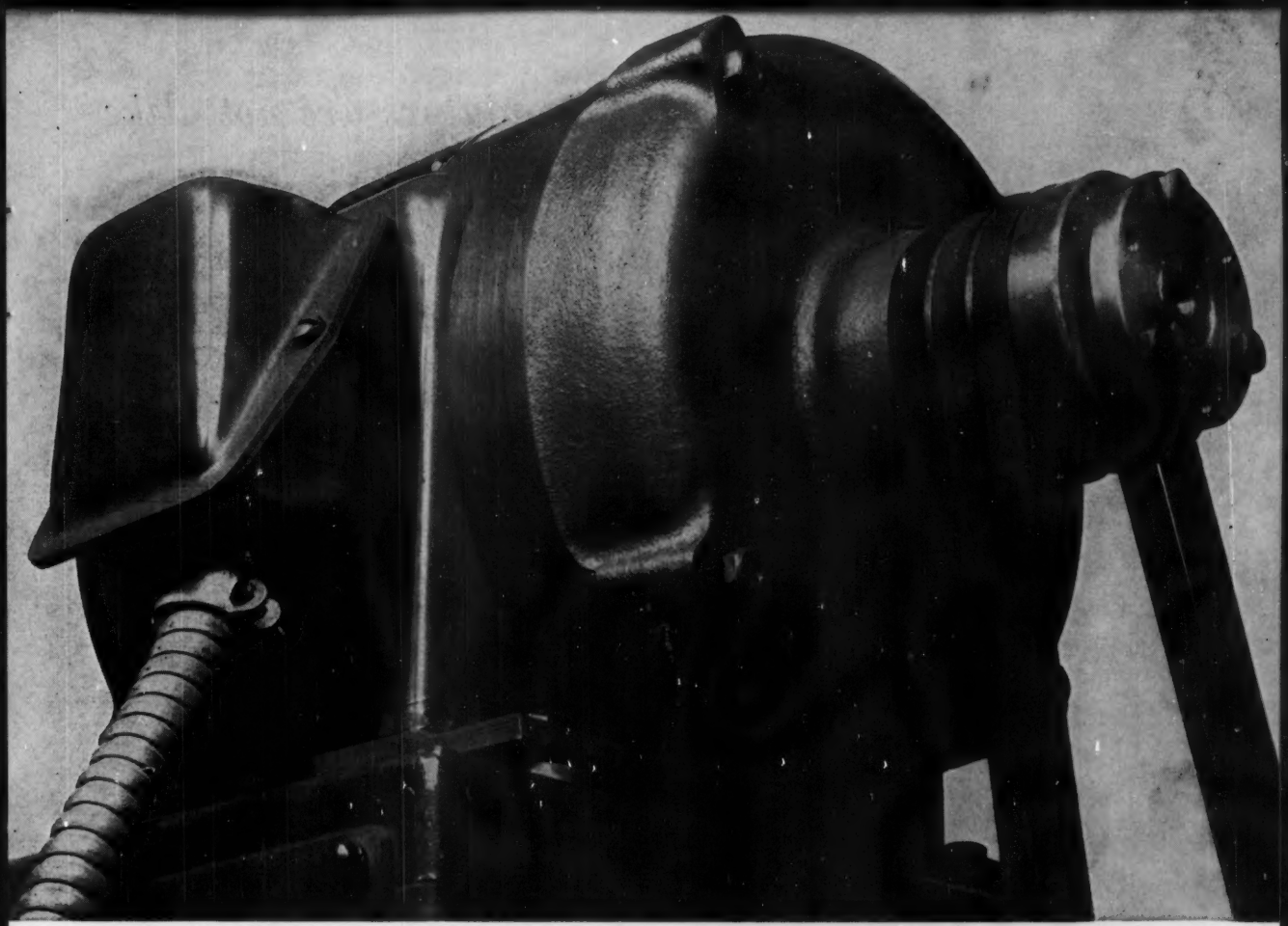
QUALITY AIR CONTROL PRODUCTS

Circle 506 on Page 19

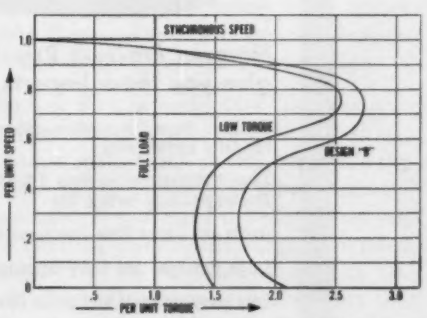


Special Century Motors Control Belt Screech

These Century polyphase motors are designed for *low* starting torque. They are mechanically interchangeable, rating for rating, with Standard Design B motors. But, as shown in the speed-torque curve, they are internally designed for static torque only 50% more than full load torque. There are some applications where this low torque at standstill is an advantage.

Belted drives have always been the cause of some noise—the same disturbing sound made by tires skidding on pavement. Flat belts had a characteristic sound at all times, varying from a "singing" sound to a real "screech." In recent years, quiet belted drives have been possible with the universally used V-belts. A continuing problem has been to start the driven machine without a few seconds of screech. When the typical motor (Design B or Design C) is energized, it develops so much torque that even properly applied V-belts are apt to screech as they bite into the sheaves. In many locations this noise is objectionable. And the high starting torques impose unnecessary strains on the driven machine.

For driven machinery (such as blowers) having a low starting torque requirement, we have found that the objectionable noise can be eliminated by this special design motor. This proved to be a simple solution to a vexing problem for several of our customers. For help on your motor problems, call your Century Sales Office.



Comparison of typical rating — NEMA DESIGN "B" and SPECIAL LOW TORQUE DESIGN

CENTURY ELECTRIC COMPANY

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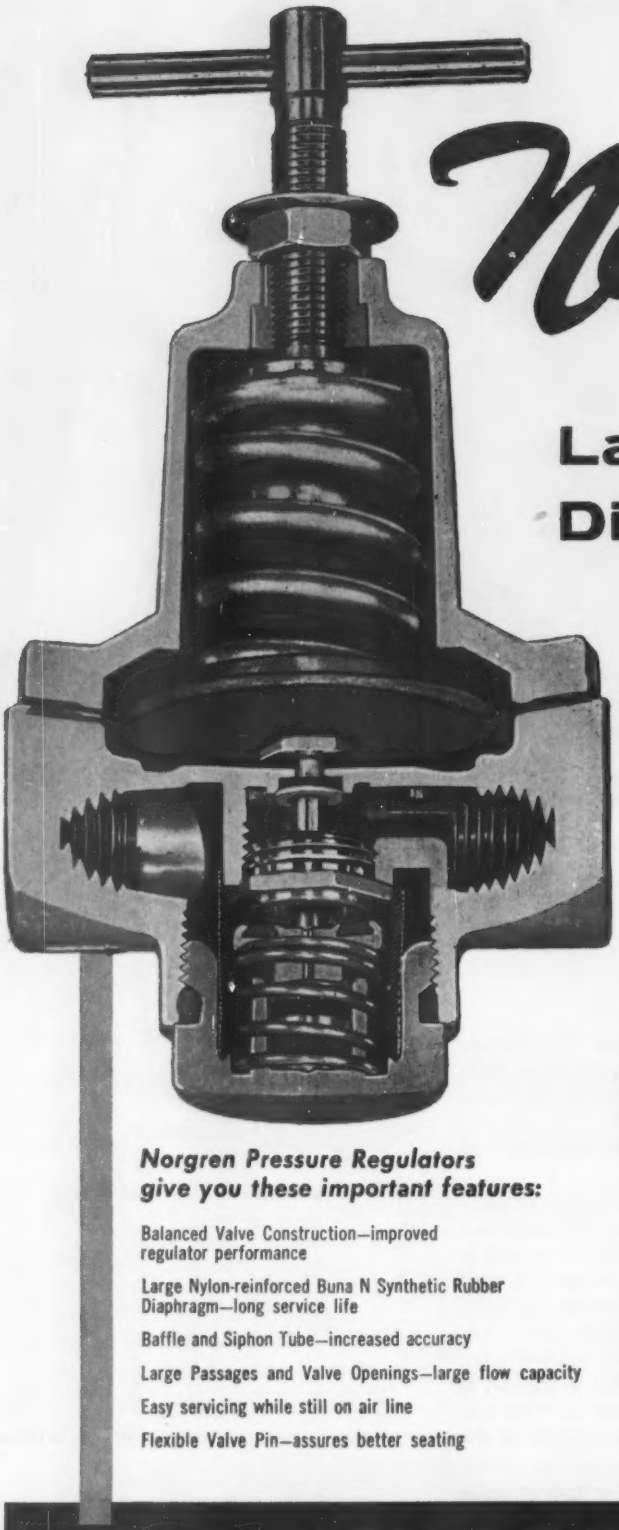
Circle 507 on Page 19

Century

60-1

All Pressure Regulators are not alike

Norgren



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provides closer pressure regulation

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Any slight deviation in regulated pressure, either as a result of fluctuating line pressure or varying flow demand, results in a greater total change in the force exerted by the diaphragm against the regulating spring. The valve immediately provides compensating action. This makes possible a highly uniform regulated pressure.

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The Norgren diaphragm is made of nylon-reinforced Buna N synthetic rubber, a combination that provides extra-long service, resulting in longer regulator life, more dependable operation and minimum maintenance.

Norgren Pressure Regulators give you these important features:

Balanced Valve Construction—improved regulator performance

Large Nylon-reinforced Buna N Synthetic Rubber Diaphragm—long service life

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Large Passages and Valve Openings—large flow capacity

Easy servicing while still on air line

Flexible Valve Pin—assures better seating

For complete information on all your regulator needs, ⅛" to 2", call your nearby Norgren Representative listed in your telephone directory—or WRITE FACTORY FOR DESCRIPTIVE LITERATURE.

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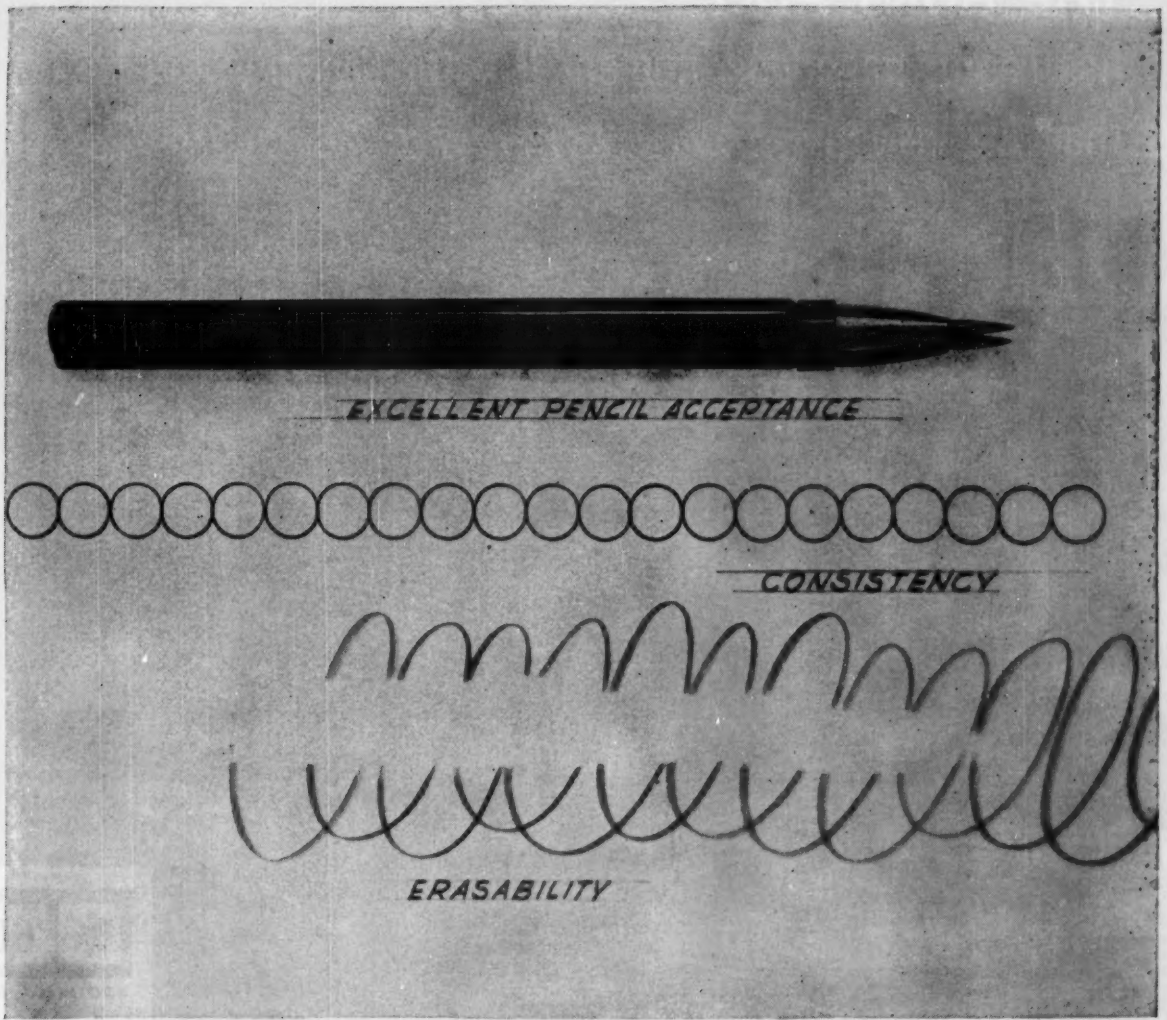

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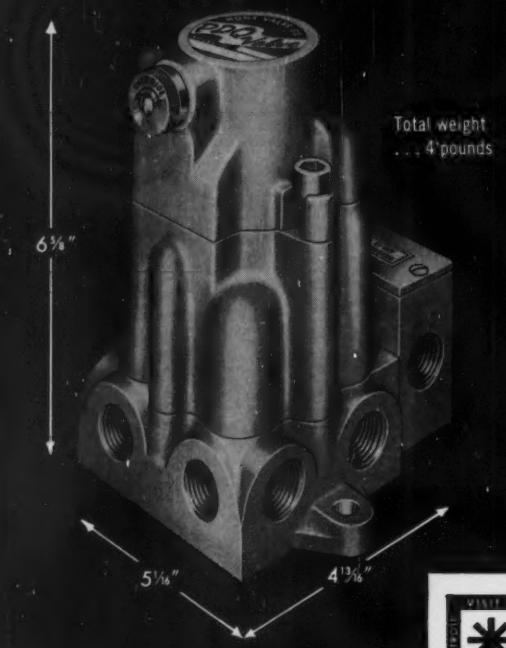

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The Hunt PDQ valve tops them all in every class.

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HUNT HVC **Quick-As-Wink** AIR & HYDRAULIC CONTROL VALVES

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MACHINE DESIGN
April 14, 1960

For Bosses Only

PUT two people together to get a job done—and you've got problems. Make it a dozen or a hundred, and you've got lots of problems. One of the problems seems basic and inescapable.

The output of a dozen never quite equals the output of twelve times one, or six times two, or four times three. As that phenomenon is pondered, somebody always says: "Well, that's Parkinson's Law for you." For each man added, output from the total crew is not proportionately greater.

This thing seems to be one of the laws of nature. Perhaps organizations can never quite beat it. The challenge is how to live with it—profitably.

In the article beginning overleaf, Sidney Sobelman outlines methods for making gains in one area: How to shrink the time that it takes to get a product from the idea stage into production. The premium for producing something ahead of the other fellow can be a fortune—or more. When the stakes are high enough, Parkinson's cut doesn't detract much from the winnings.

That sounds like pretty big-time stuff. What about more ordinary engineering work that involves smaller odds? Where investment in development and design must be justified by solid but less-spectacular returns? Even here too often, smaller net effective output per man or per dollar is accepted as the natural result of a more complex structure.

But how much of the loss is due to other influences that could be controlled or eliminated? How many times is the course of a project punctuated with accusations of false starts, time wasted, poor phasing, brilliant but pointless performance, too much paper work, etc.? These may well be symptoms of real organization and management problems.

No matter how great the skill of a designer—and he needs more than ever today—his contribution to the total program is regulated by his supervisors and managers—for better or worse.

If you are a boss, have you checked your role lately? Are you helping to solve problems of this sort? Or are you one of them?

Ben Hummel

ASSOCIATE MANAGING EDITOR

Speeding Product Development

SIDNEY SOBELMAN
Chief
Special Analysis Branch
Picatinny Arsenal
Dover, N. J.

THE PROBLEM of improving efficiency of the design engineering of a product is not new. Intense interest is shown in this area by many design and project engineers, their managers, consultants, economists, psychologists, and operational analysts. Numerous specific "solutions" showing ingenious arrangements and new insights into human drives may be pointing the way toward better answers. However, quantitative or proved cause-and-effect relationships that are practical in the real world are difficult to find.

There are enough historical case studies of so-called "successful" operation to support argument for any favored type of organizational structure. And there are surely companies considered successful—they make a profit—*in spite of* their current company structure. It appears that organization charts by themselves don't spell the difference between an organization's success or failure in meeting objectives.

A most important type of study concerns people and their drives and motivation. Fine work has been done in this area. There have also been warnings that the prime purpose of an organization is not to keep or make people "happy," but rather to get a job done. To do this efficiently, however, requires consideration of, and being in consonance with, the needs and hungers of the people who must do the job. A "management by objectives" arranges organizational conditions and methods of operation so that people can achieve their goals best by directing their own efforts toward organizational objectives. A method of operation should impose as few restraints as possible on human freedom of action or individual initiative. In this way, a sense of urgency is fostered.

The opinions and conclusions expressed are those of the author and do not necessarily represent the views of the Ordnance Corps or the Department of the Army.

Getting into production in minimum time may be as important an objective as the new product itself. Here are key factors that ought to be checked for possible gains in operating efficiency.

Is the product development team . . .

- **Staying alert to critical product characteristics?**
- **Dividing activities to overlap time sequences?**
- **Streamlining communications and report activities?**
- **Placing control and responsibility with assignment?**
- **Drawing upon specialists and support groups as needed?**

"Probably the best organization is the one that gives the most encouragement to the flow of information . . . information is the energy that drives the system design; if information does not flow, the design dries up."* Information flow and group dynamics in different types of organizations have recently been studied, but the simplification by necessity of the experimental models has hurt the practical application to the real world of system design. Nevertheless, there is evidence that difficult problems are best solved with "circular" (completely connected) type organizations, with no functional leader during the problem-solving stage. The leader again functions as such at the point of understanding or "get it done" stage.

Defining Product Characteristics

Once the properties of any product are known and once these properties are known to reflect what the customer wants, the basic elements of the organization that has to build these properties into a product design can be shown. There are seven basic product characteristics, each of which has an iden-

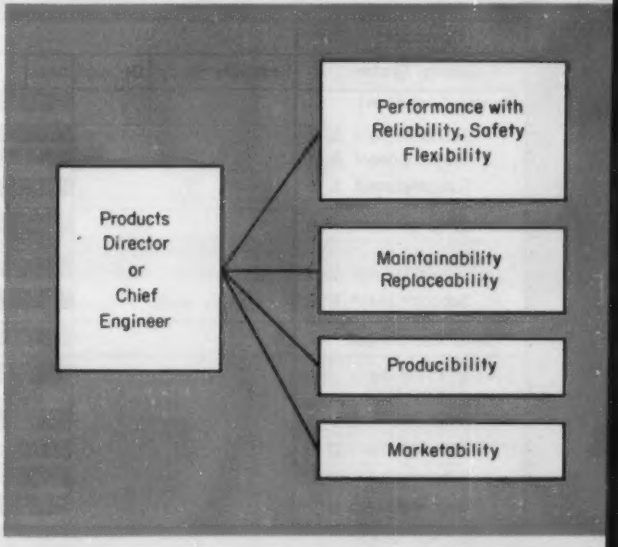


Fig. 1—Natural departmental grouping of product characteristics

*Harry H. Goode and Robert E. Machol—*System Engineering*, McGraw-Hill Book Co. Inc., New York, 1957.

tifiable class of costs:

1. Reliability of performance—cost of getting duds
2. Safety—cost of malfunctions
3. Maintainability—cost of maintenance in service
4. Producibility—cost to fabricate
5. Marketing—cost of marketing and customer training
6. Flexibility—cost saved by ease of future improvement
7. Replaceability—cost of replacing or removal from market

These seven characteristics fall into natural groups by the very nature of the engineering work. This grouping, Fig. 1, is not critical and can be changed for different organizations. It is common practice to place the engineering functions of a company or agency dealing with R & D or new or improved products into a separate and complete new-product department, the research and engineering laboratories, etc.

Scheduling Design Programs

To guide and co-ordinate activities, a plot of expected performance—a Gantt load chart—is made, Fig. 2. The process is:

1. Divide the plan into a comprehensive set of operations. Each operation must be complete before the plan as a whole is complete. Once begun, it is assumed that each operation must proceed relatively independently of progress in others. Because operations are independent, it will generally be found that each operation turns out to be a component or subcomponent development, such as development of an amplifier, motor, control valve, or switch system. Also, each may be handled by a specialist or a specialty department.
2. Divide each operation into a sequence of phases. A phase connotes an independent or separately identifiable activity which is part of a cycle because of dependency of one phase on preceding or following phases. A basic cycle consists of five phases: Analyze, design, fabricate, test, report. Repetition of the phase cycle may be necessary.
3. Estimate time required for each (or allocate time available), and plot on the chart, Fig. 2.

Basic reasoning is involved in the recommendation for subdivision of a development operation into the smallest groups of independent activities. Reduction of original time span T_s by increase in number of equal subdivisions n and elimination of portion m not overlapped is shown by

$$T_f = \frac{T_s}{n}\,[1 + (n - 1)m]$$

where T_f is final reduced time. This is represented graphically in Fig. 3. If $m = 0$ (no overlap), and all work starts simultaneously, the maximum benefit of reduction is achieved and $T_f = T_s/n$.

Integrating Design Efforts

The development of a product, or of any component of a product system, is and must be a simultaneous effort to incorporate all of the seven product characteristics (or customer requirements). If any of these seven is slighted or not considered, the development will suffer for this incompleteness at a later date. Incomplete incorporation of "pro-

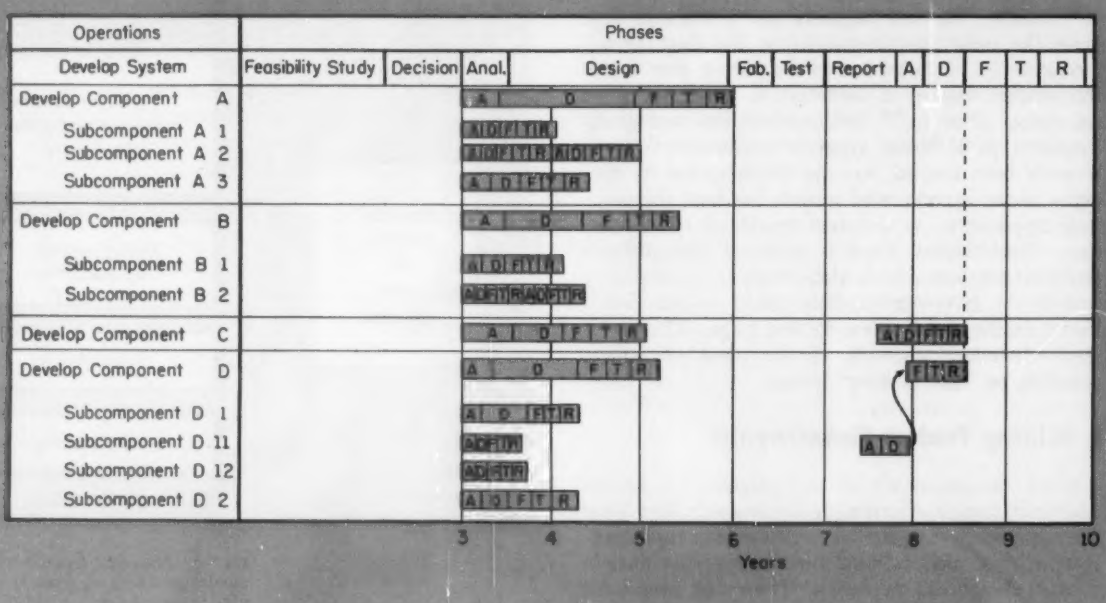


Fig. 2—Estimated time-sequence plot for product development.

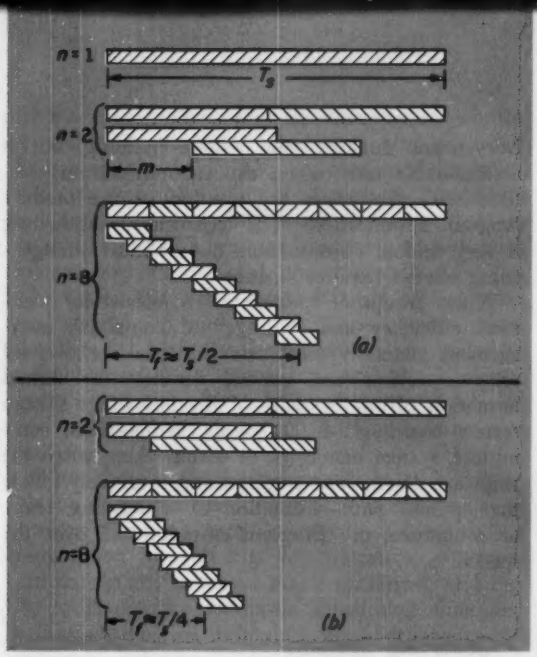


Fig. 3—Reducing product development time by subdividing and overlapping activities. 50 per cent overlap ($m=0.50$) is shown at *a*; *b* shows 75 per cent overlap ($m=0.25$).

ducibility" during development may cause greater costs to occur during actual production when tolerances, materials, methods, or tooling are changed in attempts to reduce cost or adapt production to existing processes.

This concept is presented in Fig. 4 which graphically shows the integrated design approach as one of several layers going through a phase cycle.

Support Services

A basic phase cycle (analyze, design, fabricate, test, report) usually requires several support services for efficient operation. Fig. 5 shows some of these with their relation to the basic phases.

Other special services to be made available are

1. Administration
2. Planning
3. Personnel
4. Information center
5. Finance
6. Transportation
7. Shipping
8. Procurement
9. Storage
10. Plant and utilities
11. Security
12. Legal
13. Patents

Synthesizing Design Activities

The seven basic product characteristics, or their arbitrary grouping to show departments, are related to the scheduling of projects in Fig. 6, where the projects are divided into operations and phases. This synthesis of Fig. 1, 2, and 4 is placed within the broken-line rectangle. The support services are shown outside the rectangle, together with the blocks for system engineers, component specialists, and the director. All activities necessary for product development are shown. The next step is to see *how* these activities are related to each other.

Actual Operating Conditions

First, there are product systems to be developed. If a product system is very simple, the system engineer, and design engineer or specialist may be one and the same person. As products become more

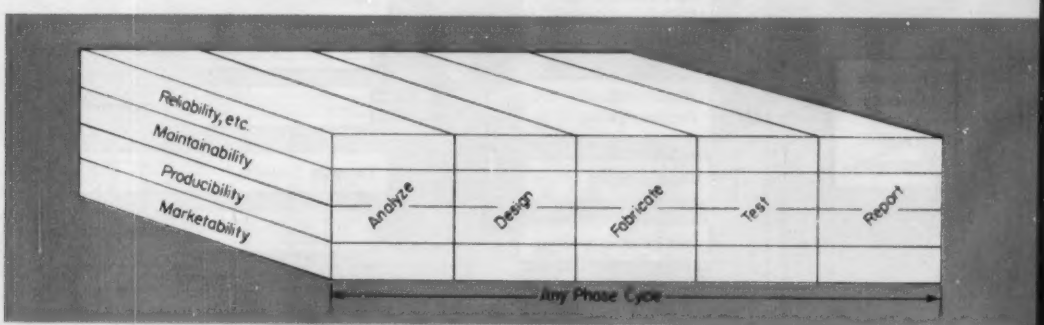


Fig. 4—The integrated design approach—progression through a phase cycle.

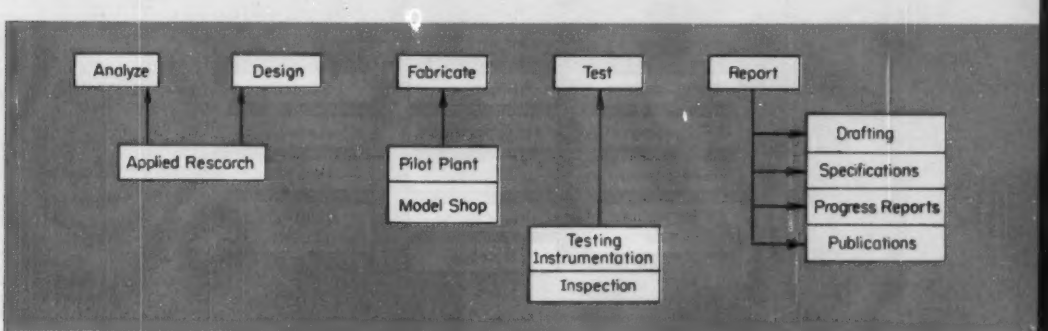


Fig. 5—Phase cycle activities and typical related support services.

complex, specialization "comes naturally" and the propellants specialist, electronics specialist, engine specialist, or refrigeration-unit specialist enter the picture. These are function and discipline specialists who assist in the product development. As required, they contribute analyses, new methods, or special skills. But the generalist or system engineer does not always (or even normally) appear on the scene.

Divisions of specialists are made according to types of engineering and customer demands or requirements (basic product characteristics). Their abilities and activities must be integrated, distinct from the component specialists who have "independent" operations in the system picture. Each engineer is intelligent and knows the information flow paths and when to use them. He is also relatively independent and self-directing. These latter characteristics are desirable because they relate to initiative, desire to participate in the decision-making processes, pride in useful accomplishments, and flexibility for adjustment to new situations.

Once an individual is identified as a specialist, there is an understandable tendency to strengthen this "recognition" both technically and politically. This "suboptimization" may lead toward isolation, ivory-tower thinking, and empire building, but is objectionable only when the suboptimization conflicts with the whole organization or the product program optimization. The technical strengthening is very seldom objectionable but political strengthening always requires scrutiny.

When groups of specialists are formed for technical efficiency and "storage" of knowhow, management generally recognizes the need for over-all progress review and control through the formal formation of one or more of the following: Design review boards, R & D boards, symposiums, committees, system managers, or teams. Also, when the chips are down, most organizations intuitively follow the optimal path—formation of a working team, or committee, or "Program co-ordinator" over the specialists.

Reporting Systems

A representation of four key specialists who have assignments in the development of a product is shown in Fig. 7*a*. Each is recognized for his intelligence, independence of specialization and action, and knowledge of the location of the other specialists. A two-way flow of information is shown between each man and any other. The contacts

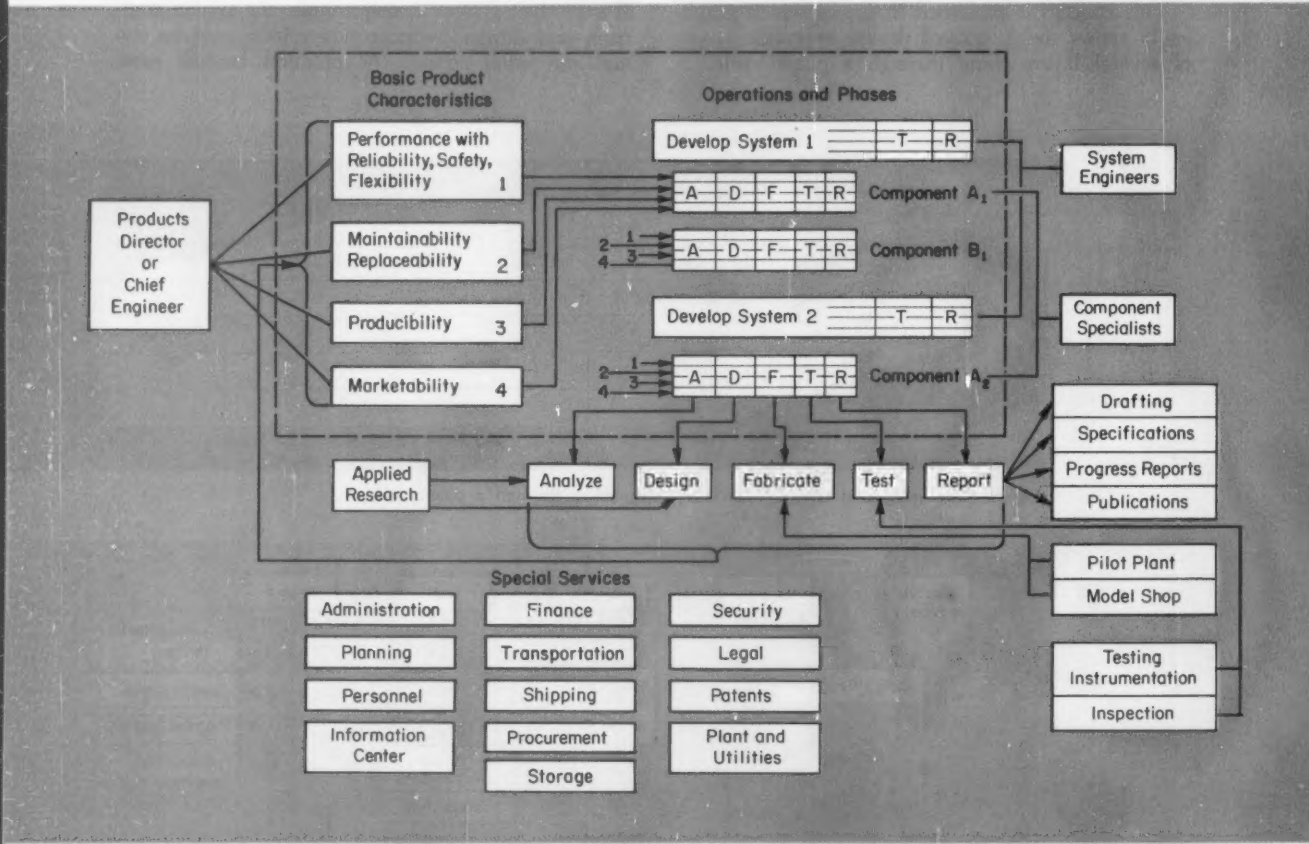


Fig. 6—Synthesis of activities of the product-development organization.

are made at random, that is, whenever a technical or scheduling problem arises with any one man. Each man also belongs to his own specialty group with its own hierarchy of supervisors, engineers, and assistants. A review board or director checks for compliance with organizational objectives through progress reports and oral presentations.

However, the other extreme—each project managed strongly by one central figure—would appear like Fig. 7*b*, with the leader or captain added as a fifth man. This completely centralized picture shows a two-way flow only between the leader and each man and no direct contacts among the specialists.

What then is the best approach to both getting the job done, and assuring that it is done so as to optimize the organization's objectives? Needed is a combination of both Fig. 7*a*, to assume minimum restraint on the technical man's initiatives, and Fig. 7*b*, to assure the minimum scheduling time and earliest solution of difficulties and bottlenecks not resolvable individually by the technical specialist. Fig. 7*c*, shows this combination. It consists of a working team and a working team captain or project manager.

A specific application is shown in Fig. 8, where the working product-development team and its captain are located within the inner broken-line circle.

Applying the Team Approach

The described method of operation has been observed in practice in a variety of organizations. It can be installed in any company without need to reorganize the "specialty," functional, or discipline groups. The team captain or leader need not necessarily be an additional man but can be one of the several specialists on the team. When the engineering team exists for the total life of the product, the captaincy or chairmanship of the team changes from the performance-design specialists to the production specialist when the product goes from development into full production, and then to the field-service specialist.

In one actual and representative case, the method of operation is a flexible combination of the traditional functional management and project management. Each functional manager is responsible for his function in the forward planning of the company as a whole. Each project manager is responsible for the successful completion of his project. He draws specialists from each functional division as he needs them for his project. Each of these men is responsible to his functional division for *how* he performs, and to the project manager for *what* he performs, and *when*.

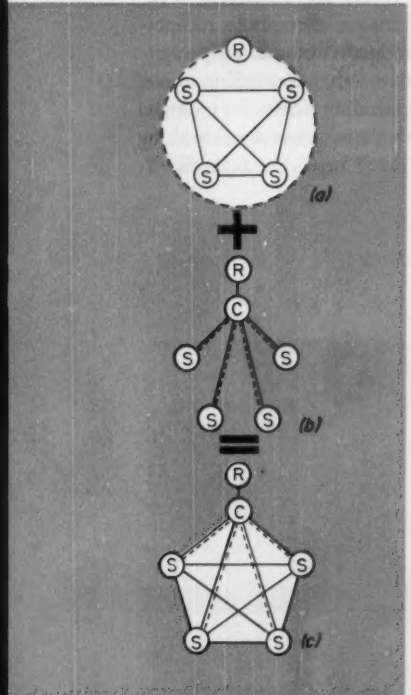


Fig. 7 — Management control and information flow in specialist areas. Individual specialists are represented by *S*, team captain by *C*, and review board by *R*. Solid lines designate paths of informal flow of information; dash-lines show management-control path.

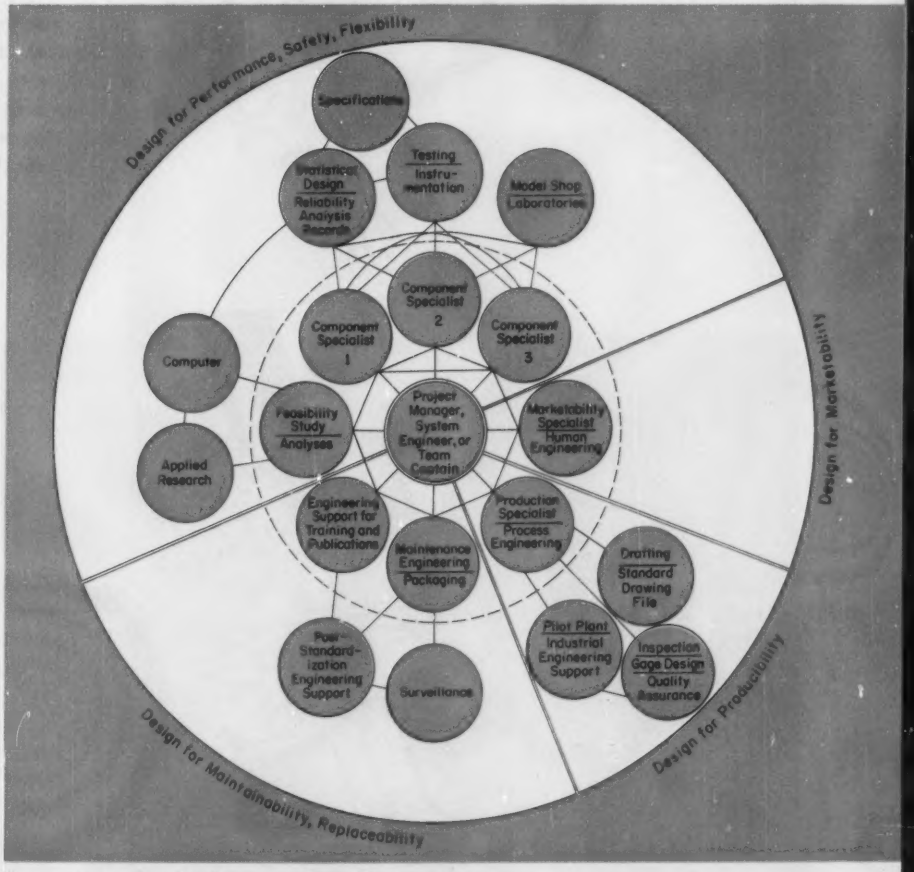
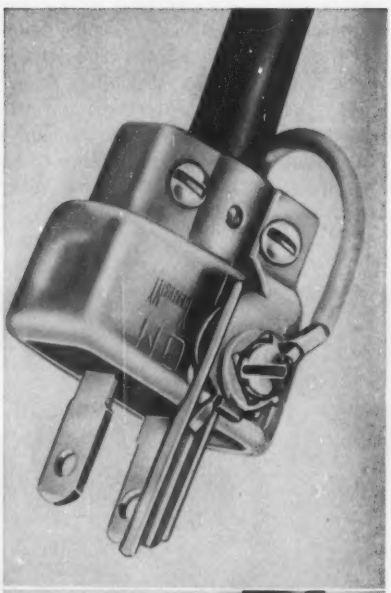
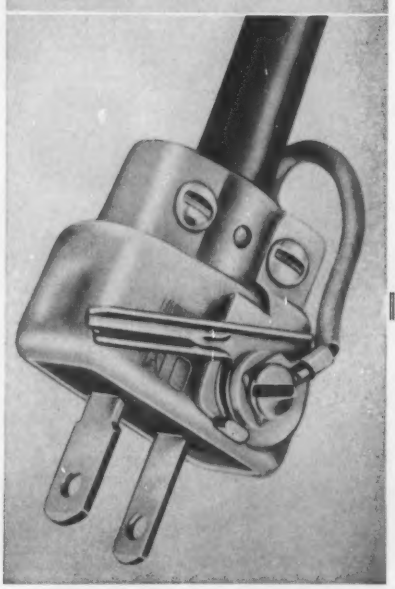


Fig. 8—A product-development team and its support.

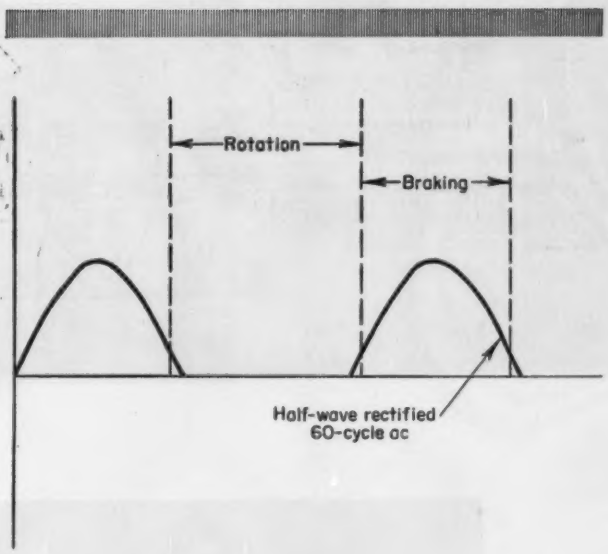
scanning the field for *ideas*

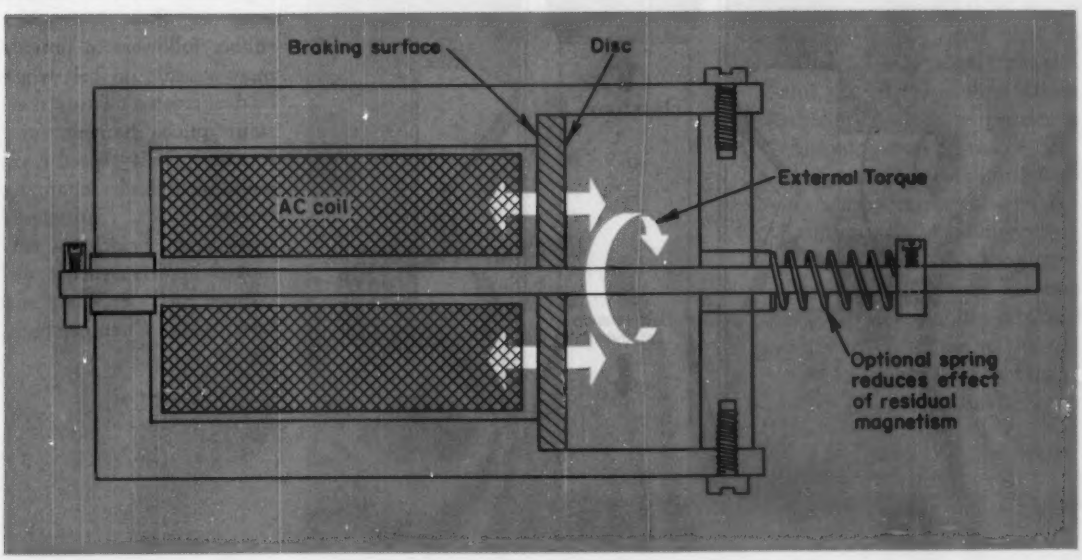




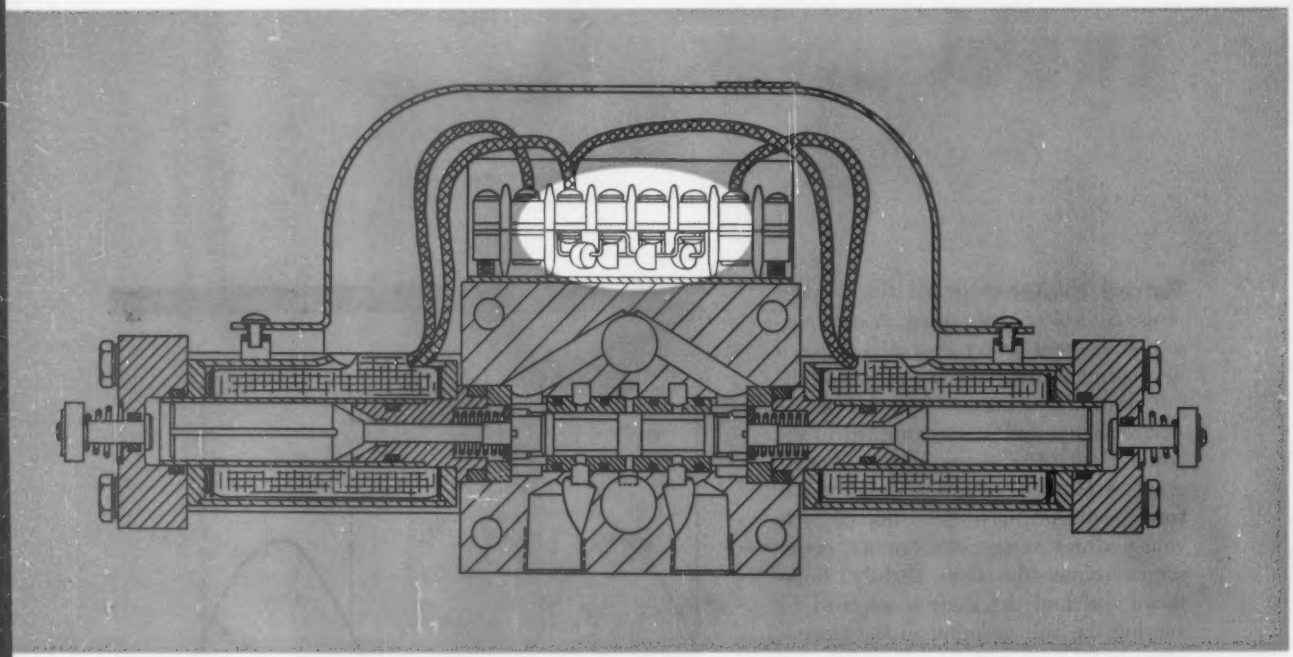
Pivoted grounding blade provides automatic self-grounding of a power connector. When the connector is inserted into a standard two-hole receptacle, the spring-loaded grounding blade deflects to one side. The chisel scraper makes grounding contact with the faceplate of the receptacle. When the connector is inserted into a three-hole receptacle, the blade automatically registers with the grounding hole. Self-grounding feature employed in power connector developed by A. P. M. Corp., Yonkers, N. Y.

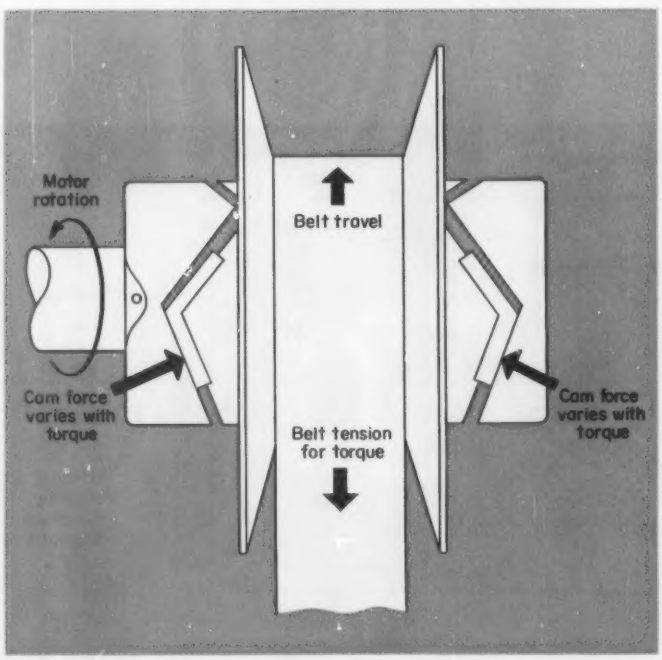
Pulsed braking produces wide-range control of shaft speed. A constant-torque external power source is opposed by the intermittent braking action resulting from the attraction between an ac electromagnet and a disc attached to the power shaft. The electromagnet is energized by 60-cycle ac power, usually half-wave rectified. Each time the 60-cycle voltage drops to zero, the external power source rotates the shaft slightly. Rotational speed of the shaft is adjusted by varying the voltage input to the electromagnet. Variable retarding principle employed in speed-control device developed by Fred Lichtgarn, Northlake, Ill.



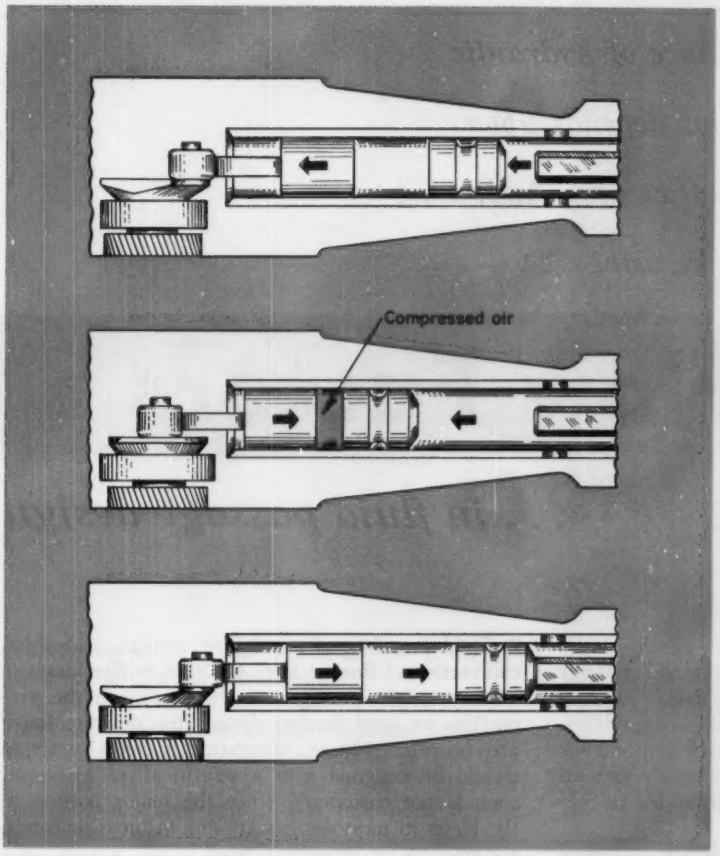


Piggy-back rectifier, tucked away in the electrical terminal strip, permits cool operation during rapid cycling of an ac solenoid-operated four-way valve. The full-wave, silicon-diode rectifier supplies direct current to the solenoids. Heat-producing inrush current is eliminated, since the electrical characteristics are those of a direct-current solenoid, in which current draw is not materially affected by solenoid armature position. Electrical principle employed in solenoid valve developed by Waterman Hydraulics Corp., Evanston, Ill.

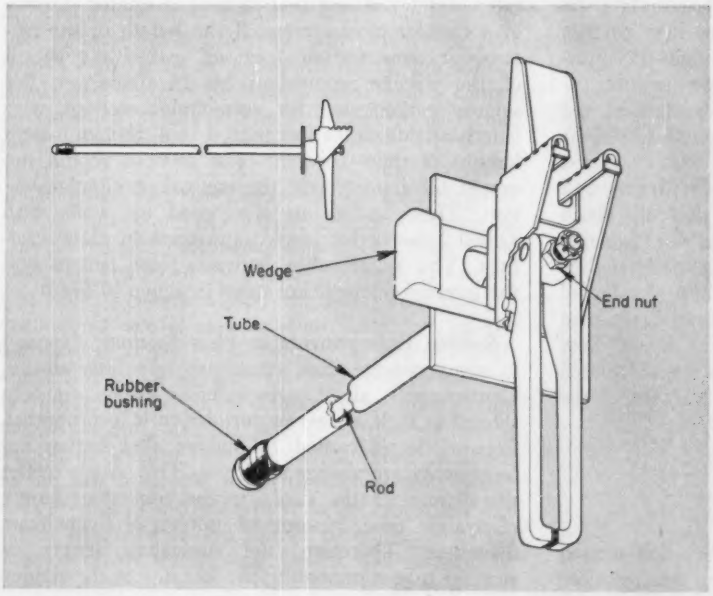




Cam tensioner assures maintenance of constant speed of V-belt under varying loads. Chevron-shaped cams act through resilient rubber followers to provide more squeeze on belt when load increases. Thus, constant pitch diameter and constant belt speed are maintained under changing torque loads. Automatic tensioning principle employed in drive sheave developed by T. B. Wood and Sons Co., Chambersburg, Va.



Trapped air transmits energy of a reciprocating piston to a striker. As the piston travels away from the striker, vacuum draws the striker along. When the piston reverses, the striker continues momentarily in the same direction. The resulting air pressure is added to that created by the outward travel of the piston. The combined pressures provide driving force to reverse the striker's direction and deliver a blow to workpiece. Drive principle employed in hammer developed by Skil Corp., Chicago, Ill.



Torqueless tensioning of a rod is produced by wedge action. The end nut is wrenched to nominal tightness, and the wedge is then driven with a hammer to provide a tensioning load on rod. A concentric shaft is combined with the rod to compress a rubber bushing axially. Lateral expansion of the bushing provides an anchor grip for bolt assembly. Tensioning principle employed in strata bolt developed by Dowty Mining Equipment Ltd., Ashchurch, England

Predicting performance of hydraulic or pneumatic systems depends upon knowledge of flow efficiency. Analyzing losses is simplified by using . . .

Flow Factors

. . . in fluid passage design

A QUESTION most frequently raised in the design of hydraulic or pneumatic systems and components is just how much pressure will be lost through the many passage configurations. Most of the methods used to obtain the answer are little more than crude approximations. And with them, true performance is almost impossible to predict prior to prototype testing.

However, the technique of flow factors discussed in this article is quite effective in minimizing inaccuracies. Whether the fluid passage is in a control valve, tube fitting, hose assembly, elbow, tee, or reducer makes little difference in the final analysis; the application of flow factors to the design is essentially the same.

Flow factors, as used in this article, correlate the pressure losses in an air stream to the flow passage configurations. The data obtained give the pressure losses in equivalent straight-pipe lengths, expressed as a certain number of diameters of the downstream section. Individual pressure losses, as well as the total pressure losses, are evaluated at the design stage by this technique. With care and practice, this method yields results that are about ten per cent above actual findings for passages with turns. Straight-through body passages give flow factors about 10 per cent greater than the actual value when pressure drops are less than 5 per cent of the absolute supply pressure. The actual flow factor may be 30 per cent less than the calculated value when the pressure loss is 40 per cent of the absolute supply pressure.

Pressure-Loss Sources

Pressure losses result from four basic flow-section characteristics: 1. Length of constant cross section. 2. Sudden enlargement of flow section. 3. Sudden contraction of flow section. 4. Turns in flow passage. When straight passage contours approach the proportions of good venturi design, the pressure losses are lessened. Hence, theoretically, most passages should be designed with a venturi effect. However, such is not customary, since the major portion of the losses in most designs are due to turns or bends, not changes in straight sections.

Friction In Straight Tubes: Flow factors for straight tubes of constant cross section are equivalent to flow factors for tubes with constant circular cross sections of an equivalent area. When air-flow friction is estimated, a rectangular cross section with a ratio of sides of less than 5 to 1 is related directly to a circular cross section, if the length of the rectangular cross section does not exceed the length of the circular equivalent by 10 diameters. For square sections and for rectangular sections with length of side ratios less than 5 to 4, the equivalent lengths of these constant cross sections should not exceed 60 diameters of the equivalent circular section. These values are also good for walls with drilled holes or for baked sand cores in metal castings. The relationship between flow factors and the internal diameters of tubes is shown in Fig. 1.

Sudden Enlargements in Flow Sections: Changes in many passage cross sections are generally abrupt. Consequently, all changes in cross section are considered as such, unless venturi design is incorporated. Pressure losses caused by sudden flow-section enlargements are shown in Fig. 2. This graph relates the diameter ratio, d_u/d_d, to the equivalent length of straight tube, in terms of number of downstream diameters. Therefore, the equivalent length of straight tube representing the loss due to the sudden

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enlargement is $L = d_d n$, where d_d and L are expressed in feet for this calculation.

Sudden Contractions in Flow Sections: Losses to be expected from sudden contractions in the flow section are shown in Fig. 3, in terms of diameter ratio and n. Once again, n is multiplied by the downstream section diameter, or its equivalent expressed in feet, to obtain the equivalent length of straight tube expressed in feet.

Smooth Bends: The losses occurring in smooth bends of 90 deg are obtained from Fig. 4, where the ratio of the radius of the bend to the diameter of the flow section is plotted against n. The radius of bend is measured to the center of the flow section. These bends are used only when the flow section reflects the R/d proportionality. For abrupt bends and turns with flow sections which cannot be classified as smooth bends, suggested n factors are given in Fig. 5.

Combined Pressure Losses: All of the losses due to the four basic changes in size or direction of flow sections are evaluated separately. Then, these losses are combined to express the losses in equivalent feet of straight pipe or tube. The separate evaluations are related in equivalent feet of the downstream flow-section diameter or equivalent diameter. Where a sudden enlargement or contraction is considered, the actual length of the downstream section should also be added to the equivalent length. Lengths of the flow sections must be added to the length of flow travel through smooth bends. Abrupt turns contribute such large losses that the actual length of section should be measured to the intersection of the joining flow-section centers.

In the evaluation of flow-section lengths and

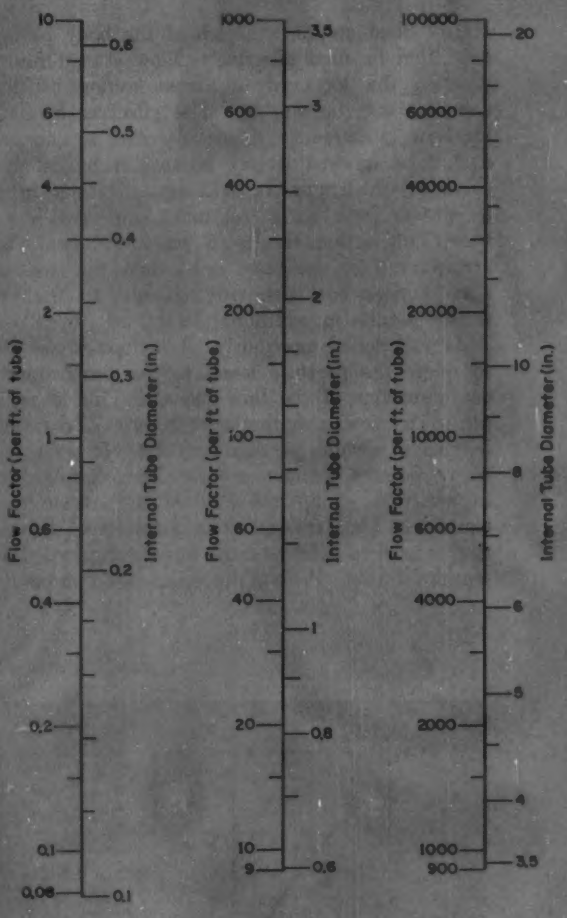


Fig. 1—Scale for converting tube diameters to flow factors.

Nomenclature

a = Cross sectional area, sq in.
d = Diameter, in. or ft
d_d = Downstream diameter, in. or ft
d_u = Upstream diameter, in. or ft
E = Equivalent straight tube length, ft
E_d = Equivalent straight-pipe length of downstream restriction, ft
E_t = Equivalent straight-pipe length of total restriction, ft
F = Flow factor
F_b = Basic flow factor for 1 foot of straight pipe (pipe size is the one arbitrarily selected for expressing component flow factors)
F_d = Flow factor of downstream restriction
F_t = Flow factor for total test restriction
L = Section length, in. or ft
n = Number of downstream diameters
Q = Flow rate, cfm (14.7 psia @ 68 F)
P_d = Downstream pressure, psi (absolute pressure)
P_u = Upstream pressure, psi (absolute pressure)
ϕ = Passage bend, deg

abrupt bend angles, a sketch of the body passages can often be used effectively. Flow streamlines indicating the locus of the cross section centroids can also aid the analysis. The effect of bends on air flow is extremely important. And so, no bend should be ignored simply because it has a short, curved path length. In addition, obstacles in the air-stream path force the maximum flow line to veer. This action results in pressure losses which are induced by the turns only, since the cross section remains constant. Any changes in the cross section results in additional losses.

As mentioned previously, flow factors are used to relate the pressure losses to the proportions or configurations of the flow passage. This is accomplished by expressing the losses in terms of equivalent lengths of circular straight sections. However, since many passage sections are far from circular, it is necessary to equate the area of the section to an equivalent circular area. The diameter of this section is used to determine the flow factor for a 1-foot length of tube. Where the losses are expressed in multiples of downstream pipe diameter, the flow factor for 1-foot length of tube of this diameter is used to determine the flow factor for the length expressed in pipe diameters.

Flow-Factor Principles

The relationship between the rate of air flow through a flow section and the entrance and exit pressures is expressed by (see Nomenclature)*

$$Q = \frac{2}{3^{1/2}} F (P_u^2 - P_d^2)^{1/2} \quad (1)$$

The constant, $2/(3)^{1/2}$, relates flow factor F to: 1. Upstream pressure. 2. Maximum air-flow rate, which chokes off to a constant for pressure ratios $P_d/P_u = < 0.5$. 3. Downstream pressure P_d, when this pressure equals one-half of the upstream pressure.

When $P_u/2 = P_d$ is substituted in Equation 1, the maximum air flow rate reduces to

$$Q_{max} = F P_u \quad (2)$$

or

$$F = \frac{Q_{max}}{P_u} \quad (3)$$

*Jubin Crocker—*Piping Handbook*, McGraw-Hill Book Co., New York, N. Y., 1945, pp. 100-103.

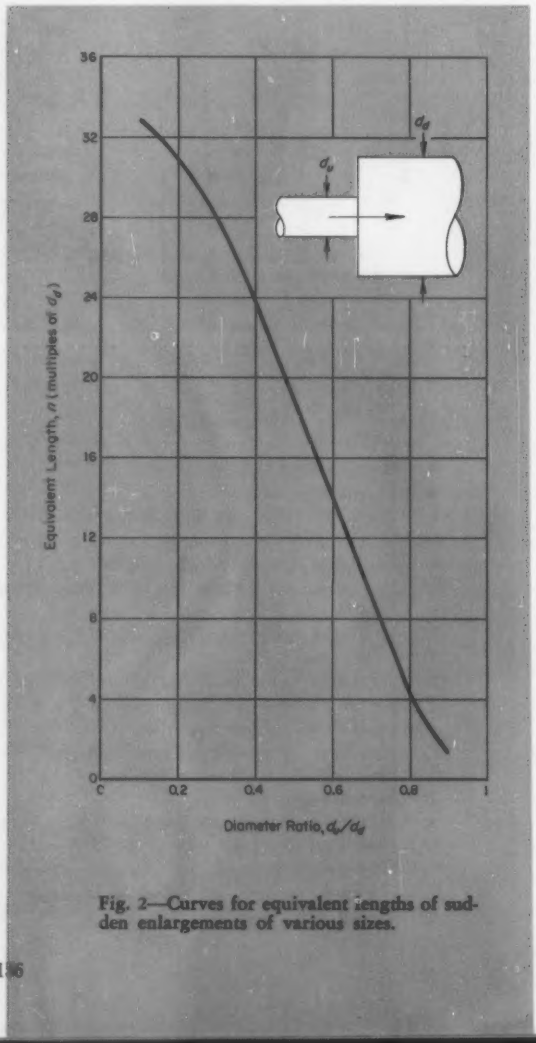


Fig. 2—Curves for equivalent lengths of sudden enlargements of various sizes.

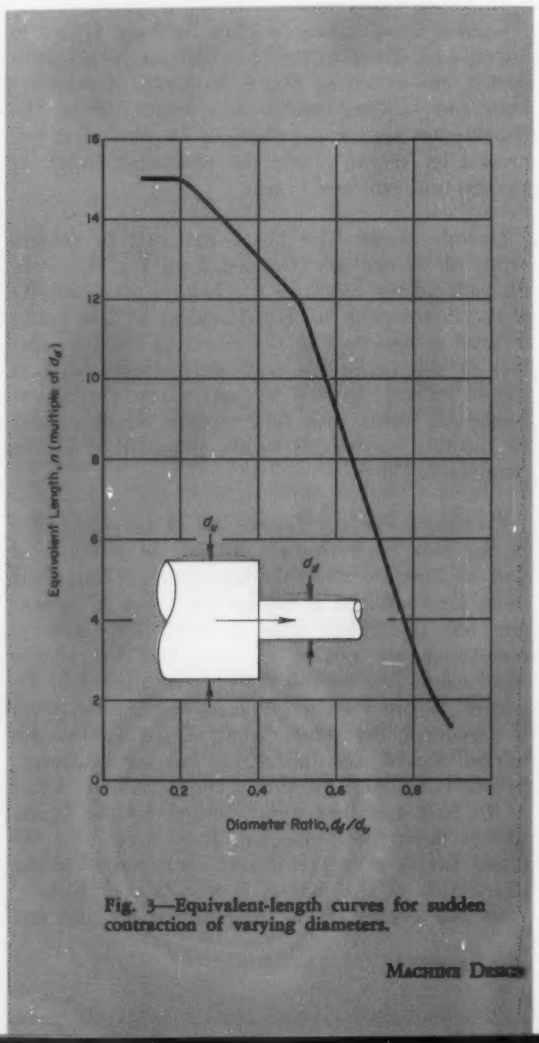


Fig. 3—Equivalent-length curves for sudden contraction of varying diameters.

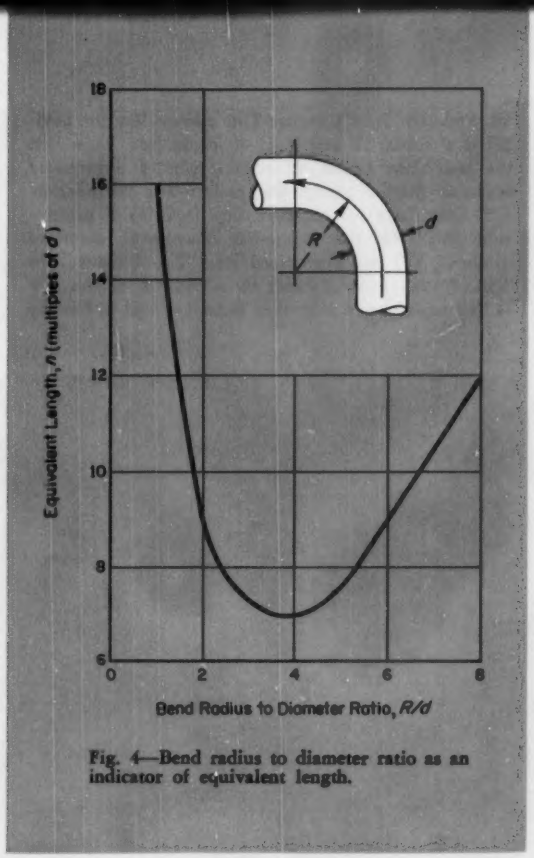


Fig. 4—Bend radius to diameter ratio as an indicator of equivalent length.

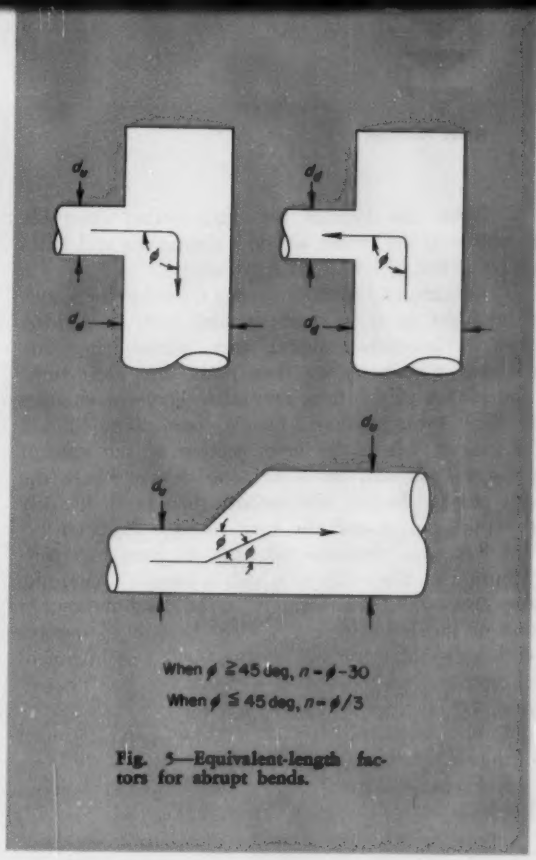


Fig. 5—Equivalent-length factors for abrupt bends.

Equation 3 is useful when the flow factor is regarded as the maximum anticipated flow per pound per square inch of absolute upstream pressure.

Test Measurement: The best accuracy for the direct measurement of F when $P_u/2 = P_d$ is possible only when the maximum fixed restriction in the system lies between the pressure taps. The downstream fixed restriction does not represent more than a few per cent of the total restriction provided by the flow component and the fixed downstream restriction. For downstream restrictions that account for 50 per cent or less of the total restriction, the error introduced is about 0.7 of the per cent of downstream restriction. This error is minimized if the maximum flow rate is based on the total restriction, and if the flow factor of the downstream restriction is estimated. Then, the equivalent length of straight pipe for the downstream restriction is deducted from the equivalent length of straight pipe for the total restriction. This correction is expressed as follows:

$$E_t = \left(\frac{F_b}{F_t}\right)^2 \quad (4)$$

$$E_d = \left(\frac{F_b}{F_d}\right)^2 \quad (5)$$

The nomograms in Fig. 6 can be used to simplify such calculations.

These nomograms are used to relate basic flow factors for 1-foot length of tube (Scale C) to the system flow factor (Scale A) in terms of equivalent feet (Scale B). Also, the respective equivalent lengths of flow sections, with different basic flow factors for 1 foot of tube, can be determined for a common system flow-factor.

Selection of Equivalent Lengths: Equivalent lengths may be expressed in many ways. Restriction to air flow through a circular cross-sectioned straight passage is a function of the section diameter. Consequently, the internal diameter of pipe, tubing, or hose determines its flow characteristics. The difficulty in relating pipe, tube, and hose sizes lies in the different designations used. Hose size is given by internal diameter, tube size is given by outside diameter and wall thickness, and pipe size is given by the nominal internal diameter which may be greater or less than the actual internal diameter. External diameters of steel pipe are the same for each nominal pipe size and the internal diameters in any one size vary with the change in wall thickness.

Calculation of Flow Factors

Orderly analysis of the flow factors for the various passages increases calculation speed. Here is a step-by-step outline of an efficient method.

1. Work with a cross-sectional drawing of the passage contours.

2. Draw the loci of the cross-section centroids to represent the center air-flow streamline and indicate direction of flow with arrowheads.

3. Indicate and identify on the drawing the planes of changes in flow cross section, such as sudden changes in cross-sectional area, planes that encompass a turn in the flow path, and each turn. The planes of the turn may also represent changes in flow cross sections. Hence, one plane should be located where the cross section of the entrant passage ends and the other one shown where the exit passage begins. For smooth-turn radii, identify the turn radius and the turn passage diameter.

4. List the character of each pressure loss contribution in the order in which it occurs. Generally, the losses fall, either singly or in combination, in one of the following categories: Length of passage with constant cross section, L; sudden enlargement of cross section, S.E.; sudden contraction of cross section, S.C.; or turn in flow streamline, ϕ.

5. For noncircular areas, determine the diameter of the circle of equivalent area.

6. Prepare a table with the following column headings:

I. FLOW SECTION: The planes identifying the location or boundaries of the passage length, containing the pressure loss contribution, are listed in this column.

II. TYPE OR SOURCE OF LOSS: The characteristics of the pressure loss contribution are entered here. Each is followed with an identification of the diameters by diameter ratio, or by the length of path, or by the angularity of the turn.

III. DIAMETER RATIO: Where applicable, put in the value found from the equation in Column II.

IV. DOWNSTREAM DIAMETER

V. EQUIVALENT LENGTH n: This column lists the values of n determined, for the diameter ratio listed in Column III, from Fig. 2 for sudden enlargement of section, Fig. 3 for sudden contraction of section, Fig. 4 for smooth 90-deg bends in flow section, and Fig. 5 for abrupt turns in flow section.

VI. STRAIGHT TUBE LENGTH: This column lists the product of Columns IV and V, $L = nd$, in feet. Term L is the equivalent length of straight tube of downstream diameter that represents the pressure-loss contribution.

VII. BASIC FLOW FACTOR: Basic flow factor F_b of straight-tube length for the appropriate downstream diameters (Column IV) are determined from Fig. 1 listed here.

VIII. ACTUAL FLOW FACTOR: Flow factor F of the tube is that which has a basic flow factor as listed in Column

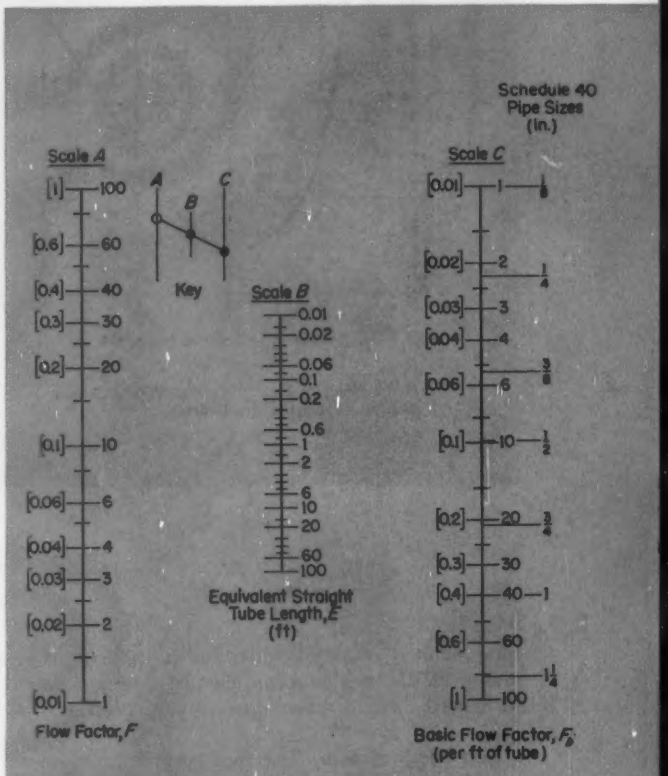
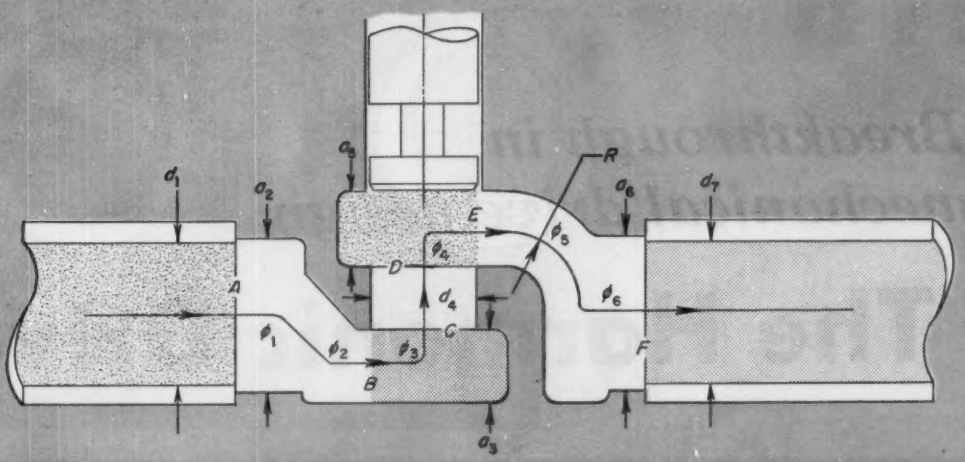


Fig. 6—Nomogram for converting basic flow factor to actual flow factor. Values in brackets of scales A and C are used together. The same is true for the values on each of these scales that are not in brackets.

Table 1—Flow Factor Determination for Valve in Fig. 7

Flow Passage Section	Type or Source of Loss	Diameter Ratio d_u/d_d or d_d/d_u	Downstream Diameter, d_d (in.)	Equivalent Length, n (multiples of d_d)	Straight Tube Length, L (ft)	Basic Flow Factor, F_b	Flow Factor F	Equivalent Length E*
A	S.E. d_1/d_2=0.824/1.20	0.686	1.20	10	1	56	56	0.15
A to B	ϕ_1=45 deg		0.833	15	1.04	21	20.7	1.05
A to B	ϕ_2=45 deg		0.833	15	1.04	21	20.7	1.05
A to B	S.C. d_3/d_4=0.833/1.20	0.694	0.833	6.5	0.45	21	31.5	0.45
B to C	ϕ_3=90 deg		0.625	60	3.13	10	5.5	15
B to C	S.C. d_4/d_5=0.625/0.833	0.750	0.625	4.8	0.25	10	20	1.15
D to E	ϕ_4=90 deg		0.833	60	4.16	21	10.3	4.2
D to E	S.E. d_4/d_5=0.625/0.833	0.750	0.833	6.7	0.465	21	31	0.45
E to F	ϕ_5=90 deg	R/d=1	0.833	16	1.11	21	20	1.15
E to F	ϕ_6=90 deg		1.20	60	5	56	23.3	0.83
E to F	S.E. d_5/d_6=0.833/1.20	0.694	1.20	9.4	0.93	56	58	0.14
F	S.C. d_7/d_8=0.824/1.20	0.686	0.824	6.7	0.46	21	31.5	0.45
								26.07 feet

*For this example, the equivalent length is for ¾-in. diameter, schedule 40 pipe.



Passage Dimensions	Diameter of Equivalent Circular Area (in.)
d_1 = 0.824-in. diam	
a_2 = 0.906 × 1.250 in. = 1.133 sq in.	d_2 = 1.20
ϕ_1 = 45 deg	
ϕ_2 = 45 deg	
a_3 = 0.437 × 1.250 in. = 0.546 sq in.	d_3 = 0.833
ϕ_3 = 90 deg	
d_4 = 0.625-in. diam	
a_5 = 0.437 × 1.250 in. = 0.546 sq in.	d_5 = 0.833
R = 0.437 in. R/d_6 = 1	
a_6 = 0.906 × 1.250 in. = 1.133 sq in.	d_6 = 1.20
d_7 = 0.824-in. diam	

Fig. 7—Typical flow-passage problem. Throttle-valve diagram is marked into areas of change in cross section and flow factors are determined for each

VII and an actual or equivalent length as listed in Column VI. Nomograms, Fig. 6, are used for this determination.

IX. Equivalent Length E: This column contains all the flow factors listed in Column VIII but converted into equivalent lengths of a common internal tube or pipe diameter. After the common internal tube or pipe diameter is selected, Fig. 6 is used for conversion.

7. Total the equivalent lengths in Column IX and indicate the reference pipe or tube size.

8. Determine the total flow factor with the aid of Fig. 6. Draw a straight line from the basic flow factor of the pipe or tube through the equivalent length as obtained from step 7, and extend the line to the flow factor.

Example: A throttle valve, Fig. 7, without the throttle in position is used here to illustrate the flow-factor analysis. The first step is to sketch the maximum velocity flow-line through the valve body as shown in Fig. 7. Then, the cross-sections and turns resulting in pressure losses are identified on the sketch and in Column I of Table 1 by sections. A notation is made in Column II, of the sudden enlargements or contractions, angularity of turns, and R/d ratio. The ratio of the diameters at the location of the sudden enlargements and contractions of flow passages are indicated in Column III. The downstream diameters in inches are listed in Column IV for all instances of pressure loss contributions. The n factors are determined with the aid of Fig. 2 through 5 and are tabulated in Column V. The equivalent lengths in feet of straight tube in Column VI are determined by the equation, $L = dn/12$, where d = diameter of the downstream section, in.

The basic flow factors for 1-foot length of tube are listed in Column VII for all of the downstream section diameters shown in Column IV. Fig. 1 is used to make this calculation. The equivalent lengths tabulated in Column VI are compared with the basic flow factors of the respective diameters to determine the flow factor listed in Column VIII. Fig. 6 can be used in this step. The separate flow factors in Column VIII are compared with the basic flow factor of a tube of common diameter to determine the equivalent length of straight section listed in Column IX. In Table 1, the basic flow factor of common internal diameter is that of a ¾-in. nominal diameter pipe, schedule 40. This is also the port size of the valve body. The equivalent lengths in Column IX are totalled at the end of the column.

The flow factor of 4.15 is determined from Fig. 6 for 26.07 feet of straight, ¾-in. nominal diameter, schedule 40 pipe. For this example, the lengths of the flow sections were omitted because they are a minor part of the total restriction.

Breakthrough in mechanical drive design:

The Harmonic Drive

What it is . . .

A new class of constant-ratio mechanical drive systems for power transmission, angular positioning, or motion conversion.

How it works . . .

A continuous deflection wave generated in a flexing spline element achieves high mechanical leverage between concentric parts.

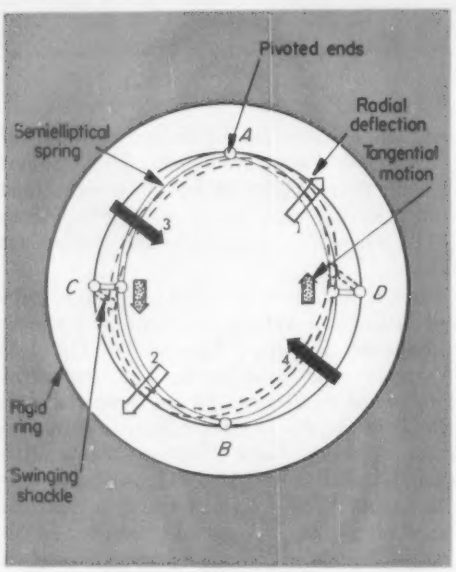


Fig. 1—Conversion of radial deflection to tangential motion by leverage action within a ring. Semielliptical spring sections are pivot mounted at points *A* and *B*, and attached by swinging shackles at *C* and *D*. Outward radial deflection in regions 1 and 2 increases spring curvature in these regions, and decreases curvature in regions 3 and 4. As a result of this radial deflection, shackles move tangentially.

DESIGN of most mechanical drive systems in use today is based on the set of "laws" collectively defined as "rigid-body mechanics." Rotating elements are assumed to remain rigid and to rotate circularly about fixed axes.

Departing radically from these traditional concepts, a new family of drive systems has recently been developed. They use controlled elastic deflection of one or more parts for transmission, conversion, or change of mechanical motion. Called Harmonic Drive, these systems achieve high mechanical leverage by generating a traveling deflection wave in a flexing spline element.

A simplified form of the principle of controlled elastic deflection is illustrated in Fig. 1 where semielliptical springs are the flexible component.

Conversion of the simple spring-deflection system into a continuous rotational machine is shown in Fig. 2. Here, two toothed rings are in partial mesh. The rigid outer ring has internal spline teeth; the thin, flexible inner ring, external spline teeth.

The third element in this rotary system is the "wave generator" which rotates within the flexible

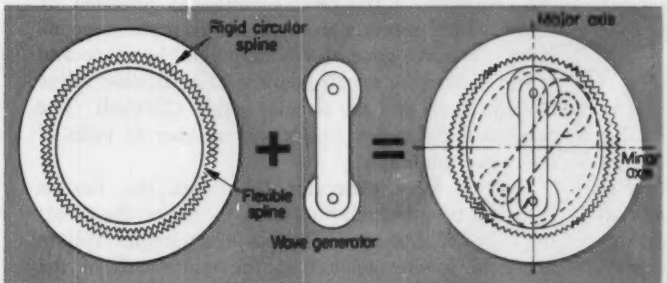


Fig. 2—Basic 3-element rotary drive system using principle of controlled deflection. In this arrangement, which is analogous to the simple spring system of Fig. 1, rotation of wave generator produces radial deflection and tangential motion of flexible spline.

What it can do . . .

Change speed with reduction ratios to 1 million:1 and transmit motion through sealed enclosures.

Basic principle of the Harmonic Drive was first announced in 1957. However, details of the drive design and its development have been kept under wraps. Up to now, the only engineering information available has been that contained in the basic patent which was filed over 5 years ago. Here, for the first time, are the complete details of the drive, its operating principles, performance characteristics, design alternatives, and application possibilities.

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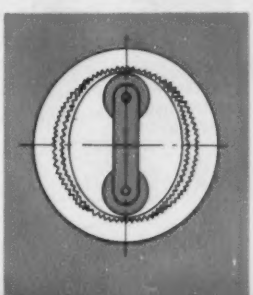
spline and deflects it slightly from its natural circular form into an elliptoidal shape. The wave generator develops the radial force and displacement illustrated in the system of Fig. 1.

With the two-lobe wave generator shown in Fig. 2, the flexible spline meshes with the circular spline at two diametrically opposite regions on the major axis of the elliptoid. Teeth of the two splines clear at the minor axis.

Teeth on the flexible and circular splines are cut to the same circular pitch. But the number of teeth on the smaller flexible spline is slightly less than on the circular spline. To allow engagement at two diametrically opposite regions, the tooth arrangement must be symmetrical. For a two-lobe system having two regions of tooth engagement, the difference in number of teeth on the two splines must be an integral multiple of the number of lobes; that is, 2, 4, 6, etc. The pitch circle of the flexible spline is made smaller than that of the circular spline in proportion to the difference in the numbers of teeth.

The regions of spline engagement in Fig. 2 correspond to the pivoted ends *A* and *B* of the semi-elliptical springs in Fig. 1. The minor-axis regions of spline disengagement correspond to the positions of the swinging shackles at points *C* and *D*. As the wave generator is rotated clockwise toward the dotted position shown in Fig. 2, the flexible spline is deflected progressively outward, causing continuous and greatly reduced tangential motion of the flexible spline. Motion of the flexible spline is in a counterclockwise direction for clockwise motion of the wave generator. For a full revolution of the wave generator, the flexible spline will counter-rotate through an angle proportional to the difference in the number of teeth on the two splines.

The distinctive characteristics of this drive system



can be seen from the simple model in Fig. 2. Flexible and circular splines are fully engaged at the major axis, but move angularly relative to one another at all other points, with maximum relative motion occurring at the minor axis. If the wave generator is rotated clockwise at a constant angular velocity, the flexible spline will counter-rotate at a constant, but greatly reduced, average angular velocity. This characteristic is the basis for high-reduction rotary systems.

Reversibility of this drive system is also apparent. If the two swinging shackles at points *C* and *D*, Fig. 1, are displaced in the tangential directions shown, the springs will be deflected radially as indicated. Similarly, in the Harmonic Drive, Fig. 2, a small counterclockwise rotation of the flexible spline will induce a magnified clockwise rotation of the wave generator. This characteristic is the basis for high-ratio speed-increaser systems.

Spline Motion Relationships: A better picture of the operation of the drive elements is provided by Fig. 3 which shows a working demonstration model. Here, the wave generator is elliptoidal in shape and is surrounded by a ball bearing. The flexible spline has 130 teeth and the circular spline 132 teeth. The two-tooth difference equals the number of lobes of the wave generator.

As the wave generator is turned, the flexible spline is progressively deflected to follow the rotating elliptoidal shape. Flexible and circular splines are held in engagement at the major axis of the wave generator, and are fully disengaged and clearing at the minor axis. Magnified views show successive conditions of spline-tooth engagement and disengagement. Views at the left show tooth action at any one region of the circular spline as the wave generator is rotated. Starting at the fully engaged position, the tooth on the flexible spline gradually disengages, advances, and re-engages, as the wave generator is turned a half revolution. For a full rotation of the wave generator, the flexible spline counter-rotates through an angle equivalent to 2 of its 130 teeth, giving a 65:1 reduction ratio.

In these drive systems any one of the three basic elements (wave generator, flexible spline, or circular spline) can be held fixed, and the other two used

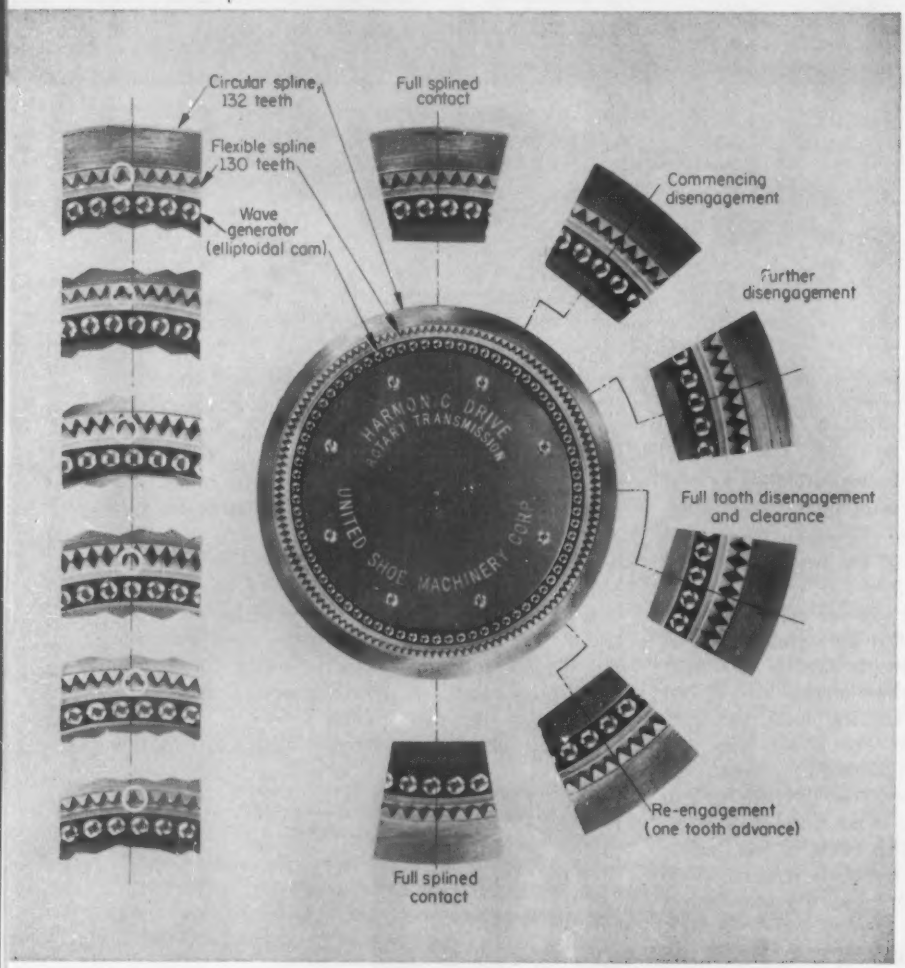
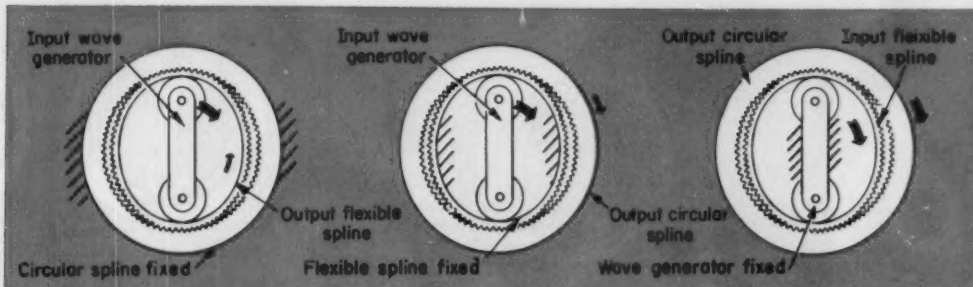


Fig. 3—Spline motion relationships in rotary single-stage drive. Magnified views at left show progressive action of single tooth during clockwise half-revolution of wave generator. Radial views show successive tooth relationships between circular and flexible splines.



Circular Spline Fixed

High input/output ratios with reversal in direction of rotation. Circular spline is stationary, input rotation is introduced through wave generator, and output rotation is taken from flexible spline. If circular spline has 200 teeth and flexible spline 198, flexible spline rotates counterclockwise two of its teeth for each clockwise revolution of wave generator, or

$$R = \frac{N_F}{N_F - N_C} = -\frac{99}{1}$$

Flexible Spline Fixed

High input/output ratio with rotations in same direction. Wave generator introduces input rotation, flexible spline is held stationary, and output rotation is taken from circular spline. If circular spline has 200 teeth and flexible spline 198, one clockwise revolution of wave generator advances circular spline two of its teeth, or

$$R = \frac{N_C}{N_C - N_F} = \frac{100}{1}$$

Wave Generator Fixed

Drive ratios near unity with input and output rotation in same direction. Wave generator is stationary, flexible spline introduces input, and output is taken from circular spline. If circular spline has 200 teeth and flexible spline 198, arrangement produces near-unity reduction, or

$$R = \frac{N_C}{N_F} = \frac{100}{99}$$

Fig. 4—Design relationships for single-stage rotary drive systems. Arrangements shown are for speed reduction service; R=drive ratio, N_C=number of teeth on circular spline, N_F=number of teeth on flexible spline. Input and output of these systems are interchangeable. They can be used for speed increase as well as speed reduction.

interchangeably as input and output. Design relationships for the basic rotary single-stage combinations are given in Fig. 4.

Design Details: Current design practice for the spline elements of these systems is based on the use of the standard 30-deg involute SAE spline tooth form. This tooth form is usually modified by changing the height slightly to allow sufficient clearance for engagement and disengagement.

However, this tooth shape is in no way mandatory. In fact, from a theoretical viewpoint, a straight-sided tooth would appear to be a better choice. But this shape would entail a special cutter for each diameter. Other pressure angles could also be used with the involute form as long as the tooth height

About the Author

Walt Musser—inventor of the Harmonic Drive—is an old hand at masterminding design "breakthroughs." He is credited with over 250 major inventions and discoveries. Some of them are the Army recoilless rifle, aircraft personnel catapults, instrumentation for underwater detonation testing, and major phases of the Marines' Ontos vehicle.

His varied career includes experience in many diverse fields. He was research advisor to the Department of Defense for 15 years. With other industrial and government organizations, he has served as chief engineer, director of research, and consultant. He holds professional engineering licenses in Pennsylvania and Massachusetts.

In his present capacity with United Shoe Machinery Corp., he is actively exploring nonrigid-body mechanics, using controlled deflection as an operating medium. Some of the results of this work are reported here. Other aspects are still in the experimental and developmental stages.

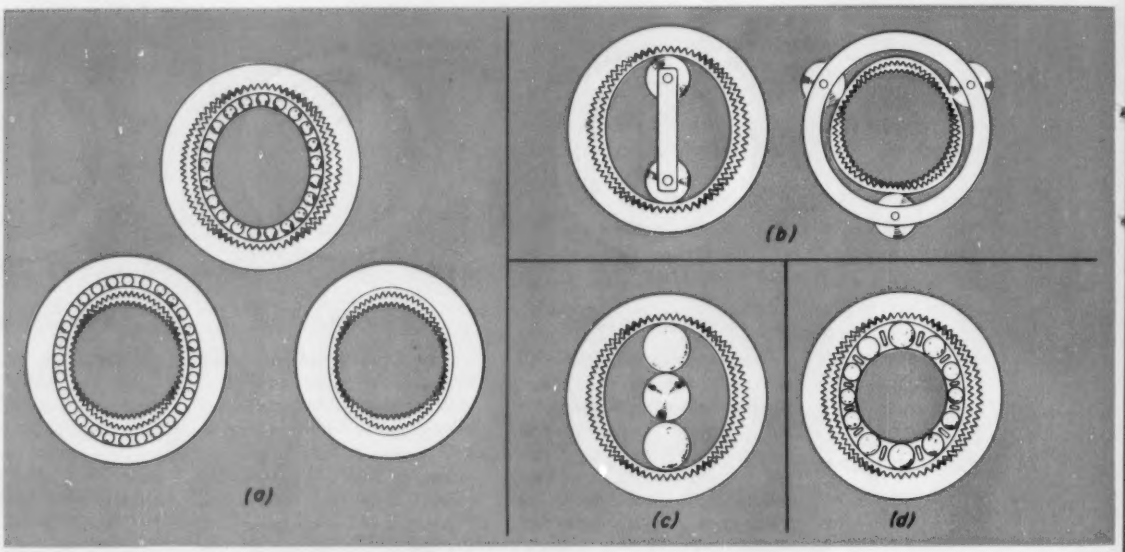
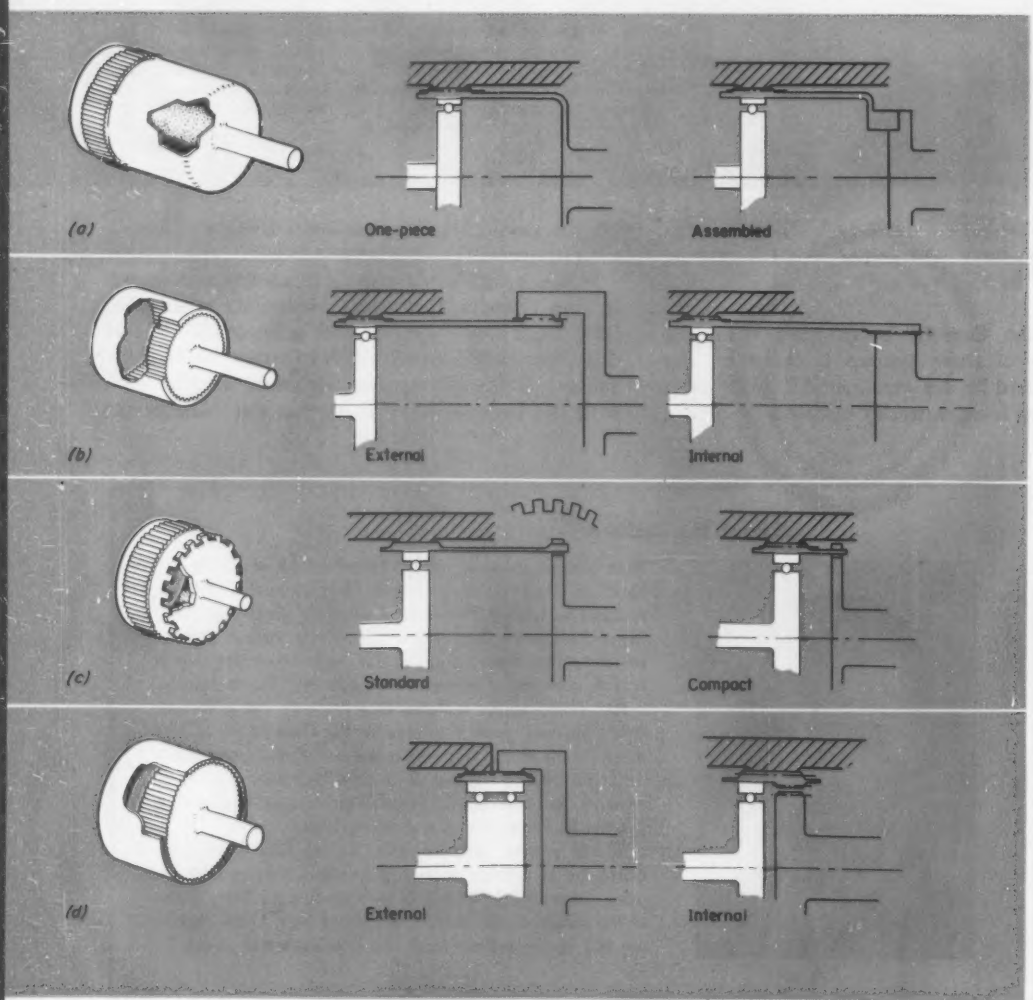


Fig. 5—Wave generator configurations: *a*, elliptoidal cam; *b*, spaced roller; *c*, ball planetary; *d*, variable-ball planetary.

Fig. 6—Types of flexible-spline couplings: *a*, integral; *b*, static spline; *c*, castellated; *d*, dynamic spline.



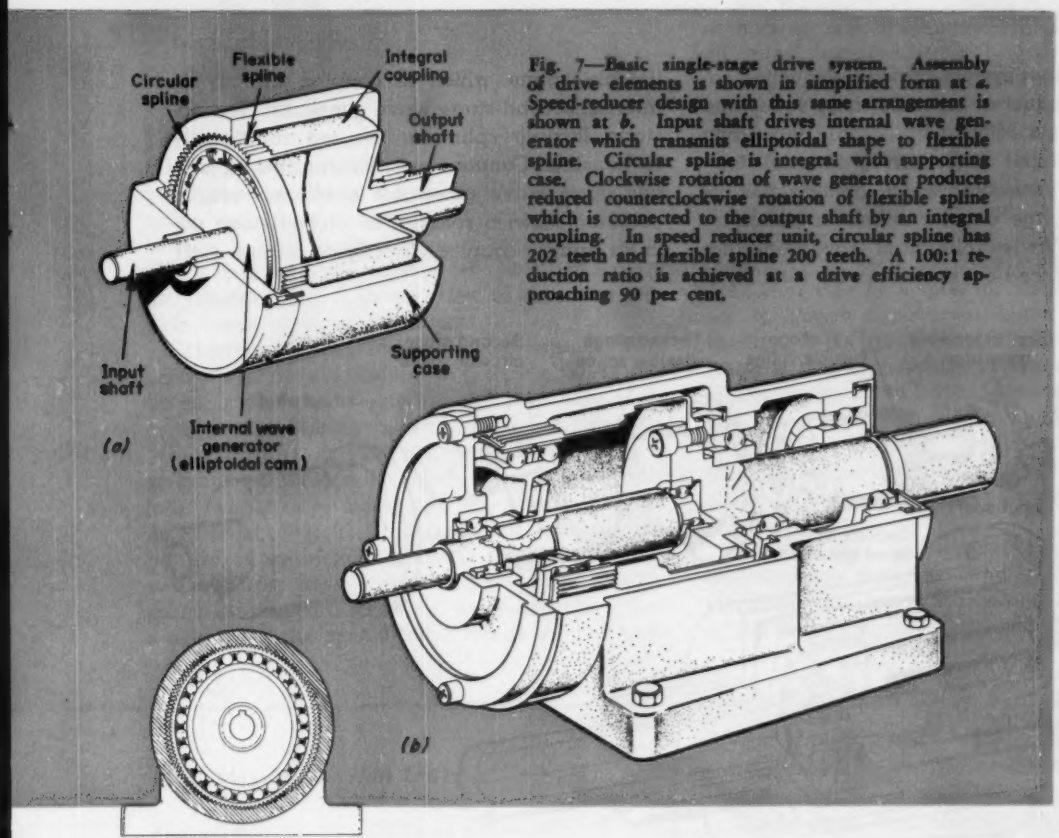


Fig. 7—Basic single-stage drive system. Assembly of drive elements is shown in simplified form at *a*. Speed-reducer design with this same arrangement is shown at *b*. Input shaft drives internal wave generator which transmits elliptoidal shape to flexible spline. Circular spline is integral with supporting case. Clockwise rotation of wave generator produces reduced counterclockwise rotation of flexible spline which is connected to the output shaft by an integral coupling. In speed reducer unit, circular spline has 202 teeth and flexible spline 200 teeth. A 100:1 reduction ratio is achieved at a drive efficiency approaching 90 per cent.

is altered to provide the necessary clearance.

A number of materials have been used successfully in the design of the drive elements. Preferred choice has been SAE 4340 steel, primarily because of the specifications on metallurgical cleanliness that have been established for this material. However, this cleanliness requirement is only of importance for those parts which are thin and have alternating stresses imposed on them. In this respect, the problems are not any more critical than for other machine elements.

Although the flexing elements are subjected to cyclic-stress conditions, fatigue has not been a particular problem. For example, the calculated maximum stress in some experimental 100:1 reduction units varies from 9000 psi for one design to 18,000 psi for another. Actual strain-gage measurements indicate that the stress level at the most highly stressed point is considerably less than the endurance limit of any steel.

Unique Properties: From the description of the basic rotary drive system, several unique and inherent properties become apparent:

1. Tooth motion relationship between flexible and circular splines makes high-ratio speed reduction or speed increase possible in a single stage.

2. In operation, many spline teeth are in simultaneous engagement to carry torque loads. Teeth adjacent to load-bearing teeth are in near-engagement and provide a "reserve" capacity to accommodate shock overloads.

3. Spline teeth come into contact with an almost pure radial motion, and have essentially zero sliding velocity, even at high input speeds. Tooth friction losses and wear are thus negligible.

4. Spline teeth in contact are practically stationary. Dynamic loading, under normal operating conditions, is negligible, and splines are thus capable of transmitting torques nearly in proportion to their static strength.

5. Regions of tooth engagement and application of load torque are usually diametrically opposed, and result in a force couple that is symmetrical and balanced.

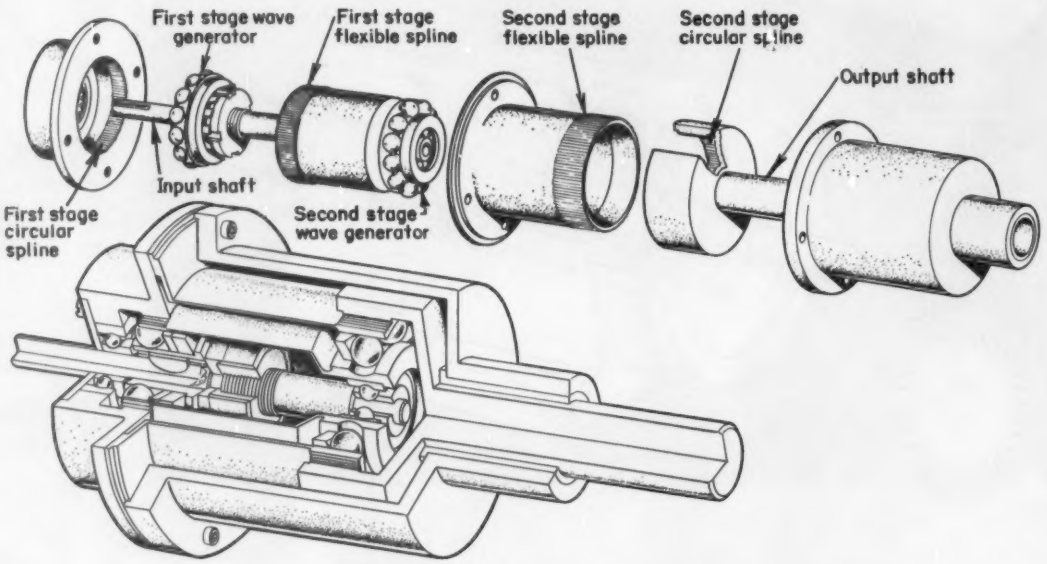
6. Diametrically opposed spline mesh and large number of teeth in simultaneous engagement result in a statistical averaging of errors in individual tooth shape and placement.

7. With the flexible spline formed as an integral section of a flexible cylindrical wall, positive transmission of mechanical motion through the wall can be achieved.

Wave Generator Configurations: Role of the wave generator is to produce controlled deflection of the flexible spline and to make possible the continuous rotation of the resulting elliptoidal shape. Up to now, the systems discussed have used internal wave generators which deflect the flexible spline outward

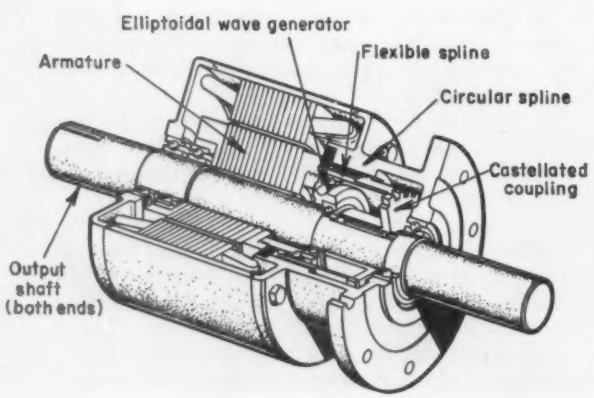
Compound High-Ratio Reducer

Two-stage drive system provides reduction ratio that is product of separate stage ratios and can range from 2500:1 to 200,000:1, depending on design. Input shaft drives internal first-stage wave generator which deflects flexible spline to engage circular spline in stationary housing. Clockwise rotation of wave generator produces reduced counterclockwise rotation of flexible spline which is coupled directly to internal second-stage wave generator. Second-stage flexible spline is secured rotationally to housing. Counterclockwise rotation of second-stage wave generator produces reduced counterclockwise rotation of second-stage circular spline, coupled directly to output shaft.



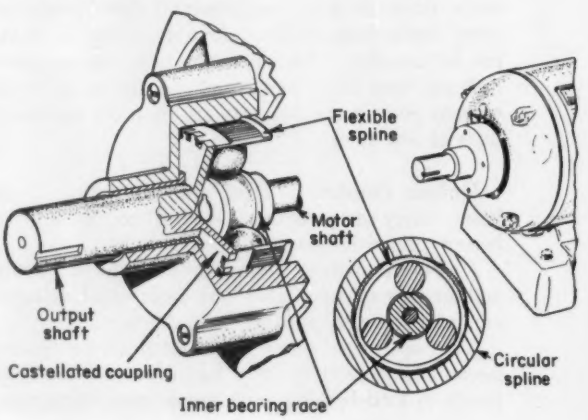
Through-Shaft Motor-Reducer

Single-stage system permits axial through-shaft design for low-speed, high-torque output at both ends of unit. Rotating armature is coupled to elliptoidal wave generator which deflects flexible spline into engagement with circular spline. Circular spline is integral with drive housing. Output shaft is joined to flexible spline by castellated coupling.



General-Duty Motor-Reducer

Minor modification of commercial motor incorporates 264:1 single-stage reduction system in end-bell. Motor shaft drives inner bearing race and three-ball planetary wave generator, producing a symmetrical three-lobe deflection wave. Flexible spline, with 240 teeth is deflected into 243-tooth circular spline in three regions. Rolling-ball reduction of 3.3:1 combines with 80:1 spline ratio to produce over-all 264:1 ratio.



into engagement with the circular spline. Wave generators can also be external to deflect the flexible spline inward into engagement with the circular spline. In this instance, spline engagement is at diametrically-opposite regions on the minor axis of the elliptoid. Fig. 5 shows a few of the many possible forms of wave generators.

ELLIPTOIDAL CAM: Most common form of wave generator is the elliptoidal-cam type, Fig. 5*a*. It may be either internal or external and may have plain or antifriction bearing contact with the flexible spline.

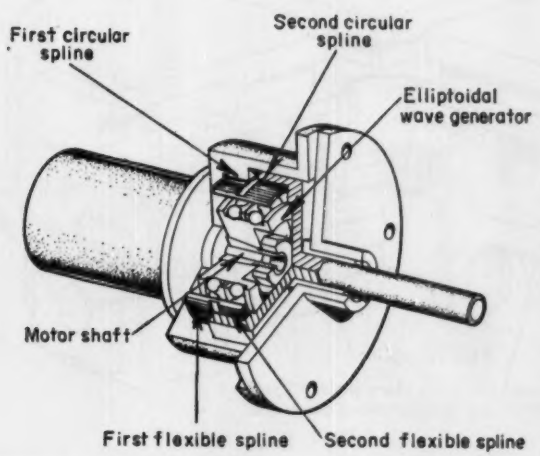
SPACED ROLLER: An inexpensive form of wave generator is the spaced roller type. It can easily form two or more lobes, and may also be internal or external, Fig. 5*b*. Standard ball bearings can be used as antifriction devices at the points of contact with the flexible spline. Because the flexible spline is unsupported between wave-generator lobes, drives using the spaced-roller design do not have as high an output load capacity as those using the elliptoidal cam type.

BALL PLANETARY: Another useful form of wave generator is the ball-planetary type, Fig. 5*c*. This consists of a circular inner bearing race which acts as a sun wheel and drives two or more radially-loaded balls. Because the balls are loaded radially, load forces are balanced and symmetrical at the regions of spline engagement. Thus, a spacer is not mandatory to keep the balls separated. However, the spacer may be helpful for assembly of the balls, and to prevent displacement under accidental shock loading. A feature of the ball-planetary wave generator is that its reduction ratio can be varied from approximately 2.2 to 8:1, to supplement spline action and increase the over-all drive reduction. When a selection of ball-planetary wave generators is available, the reduction ratio of a drive stage can be changed readily to meet a wide range of ratio requirements.

VARIABLE-BALL PLANETARY: A variation of the ball-planetary wave generator utilizes several balls of varying size, interposed between the two or three largest balls, Fig. 5*d*. These additional balls do not

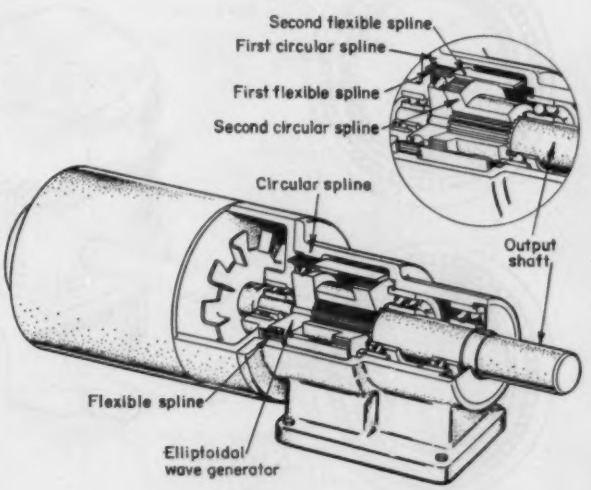
Dual-Stage Reduction Drive

Reduction ratio of 12,880:1 is produced by compact dual-stage drive arrangement. Motor output shaft drives elliptoidal wave generator, deflecting flexible double-spline element so that first flexible spline (160 teeth) engages first circular spline (162 teeth) and second flexible spline (159 teeth) engages second circular spline (161 teeth). Two sets of splines have slightly different ratios of opposite algebraic sign, producing differential action with high speed reduction.



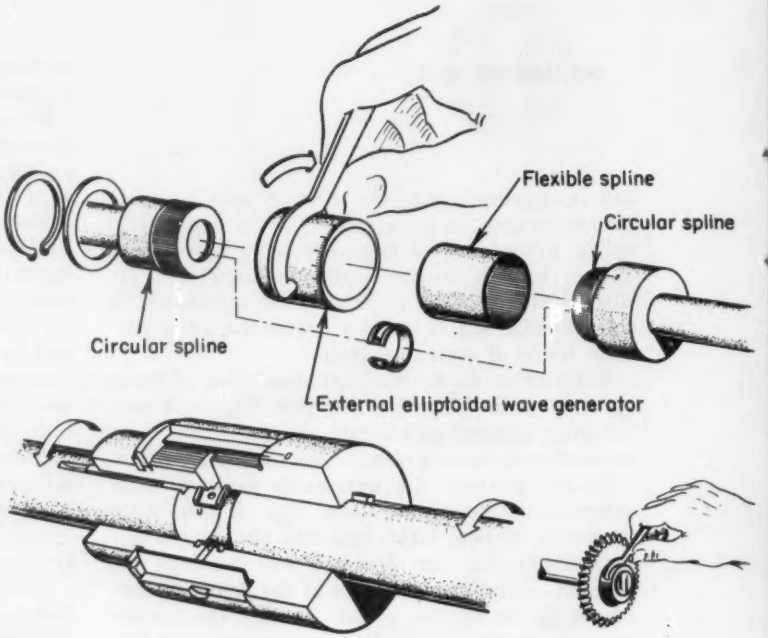
Modular Design Motor-Reducer

Single-stage 40:1 reducer system is changed to 800:1 reduction dual drive by reversing assembly position of circular spline. Full drawing shows single-stage drive, with reduction ratio determined by internal circular spline and external spline at left end of flexible multiple-spline element. The engagement at the right end is that of a conventional spline. Inset shows output circular spline reversed to mesh with internal elliptoidal spline, forming intermediate-ratio dual drive with 800:1 reduction.



Angular Phasing and Timing Assembly

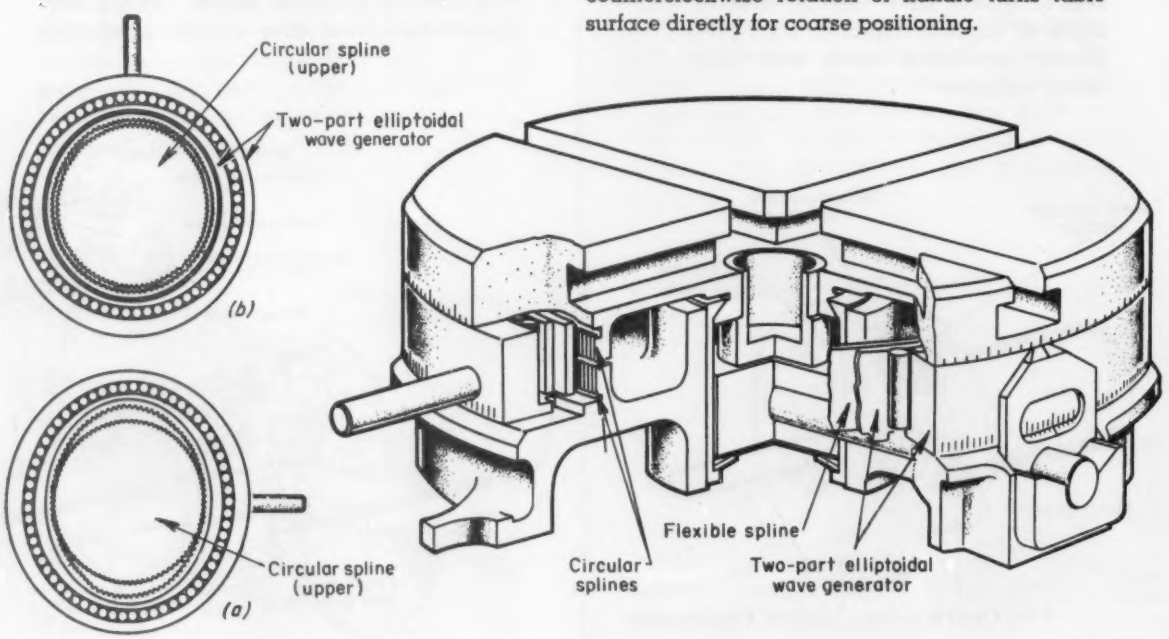
Precise angular phasing and timing of shafts, gears, or cams is achieved with assembly of standard drive elements. Flexible spline is deflected by external wave generator to engage both circular splines. To phase left shaft relative to right shaft, wave generator is rotated manually with spanner wrench. Difference in number of spline teeth causes flexible spline to rotate relative to left shaft with 72:1 reduction. But circular spline on right shaft has same number of teeth as flexible spline and engagement forms a dynamic spline coupling with 1:1 ratio. One side of system can carry a gear or cam which can be phased relative to its supporting shaft.



Precision Indexing Table

Drive system with two-part elliptoidal wave generator is used to provide fine and coarse angular positioning of work table. Lower circular spline is integral with table base, upper circular spline with table surface. Clockwise rotation of wave-generator handle, *a*, causes flexible spline to rotate relative to table base with 90:1 reduction. Upper circular spline and flexible spline form a dynamic spline coupling and rotate (clockwise) in unison. Hence, reduced motion of flexible spline is transmitted to table surface for fine positioning.

For fast positioning, wave generator handle is rotated counterclockwise, *b*. This action rotates the outer portion of the wave generator so that the two parts are "in phase," allowing the flexible spline to assume a circular shape. The flexible spline teeth disengage the teeth of the lower circular spline, but remain partially engaged with those of the upper circular spline. Continued counterclockwise rotation of handle turns table surface directly for coarse positioning.



vary the reduction ratio of the wave generator, but support the flexible spline, share the bearing load, and thus increase the torque capacity of the drive unit.

Flexible-Spline Design: The wave generator and the circular spline can be joined rigidly or rotationally to external equipment by standard coupling methods. However, the flexible spline requires less conventional techniques of position and motion coupling. For most applications, motion of the flexible spline is transmitted through a type of coupling which integrates the variations in angular velocity previously mentioned and produces a uniform angular motion. Four types of such couplings are shown in Fig. 6.

INTEGRAL COUPLING: From a performance view, the preferred flexible spline couplings are integral members, Fig. 6*a*. The coupling is in the form of a cup with spline teeth in the cylindrical wall near the open end. Controlled deflection is imposed in the cup at the open end, while the closed end remains essentially circular. The length of the tubular wall acts as a deflection attenuator, and provides a form of integrating coupling between the spline engagement at the open end and a shaft joined to the cup bottom. Integral couplings have high torsional rigidity, low backlash, long life, high torque capacity, and no power loss within the coupling. Drive efficiencies with integral couplings can be over 90 per cent. The assembled coupling can contain a drive motor, overload clutch, or electrical control circuits for effective space utilization.

STATIC SPLINE: The next most efficient coupling is the static design, Fig. 6*b*. Here, the flexing spline is at one end of an open tube and a standard circular-spline engages the other end. Coupling spline teeth can be cut either externally or internally into the tube wall. The static-spline coupling permits slight axial motion of the tube without allowing angular or radial freedom. Operating efficiency of the static spline is slightly less than that of an integral coupling. Fabrication cost is lower, but the static spline requires lubrication.

CASTELLATED COUPLING: Efficiency, positioning accuracy, and torque capacity of the castellated coupling, Fig. 6*c*, are governed by the number of lugs and the tube length between spline teeth and lugs. Maximum compactness is possible with this type of coupling. The shorter couplings, however, have about one-fourth the load capacity of an integral coupling since torque is not equally distributed among the lugs. Castellated couplings have lower positioning accuracy and efficiency, but are the least expensive and most compact coupling form for a single-stage drive.

DYNAMIC SPLINE: A unique form of spline coupling is shown in Fig. 6*d*. Teeth of the flexible spline can be extended along the inner or outer wall of the flexing tube, or teeth can be provided on both inner and outer walls. A second circular output spline engages the elliptoidal flexible spline either externally at the major axis, or internally at the minor axis. The circular output spline has the same number of teeth as the engaging spline on the flexing tube. Thus, the two splines move in unison, causing motion of the flexible spline to be transmitted directly to the shaft. The dynamic-spline coupling is compact and offers high positioning accuracy. Load-carrying capacity, however, is about one-third that of the integral coupling, and drive efficiency with this type of coupling is about 65 per cent.

Drive Systems: How the principal operating elements previously discussed are combined to form a single-stage drive system is shown in Fig. 7. This

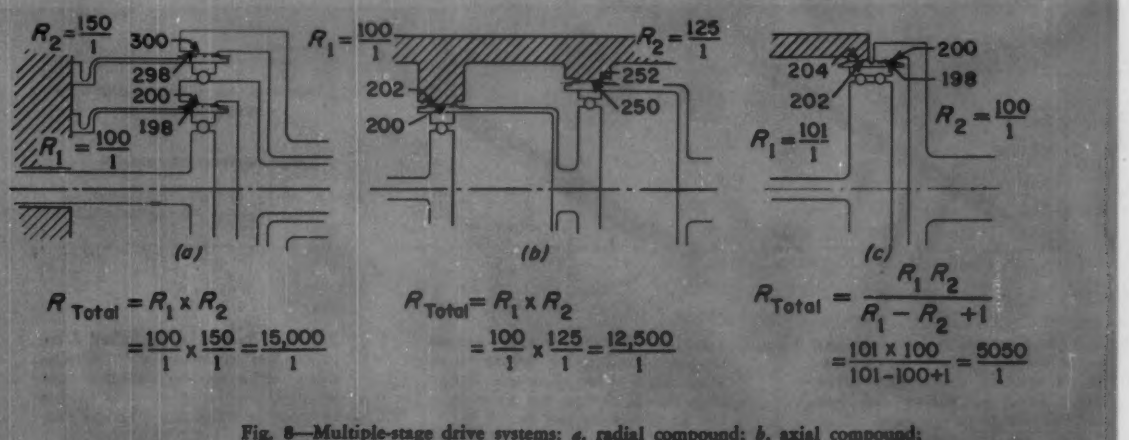


Fig. 8—Multiple-stage drive systems: *a*, radial compound; *b*, axial compound; *c*, dual. Ratio calculations are based on numbers of teeth indicated.

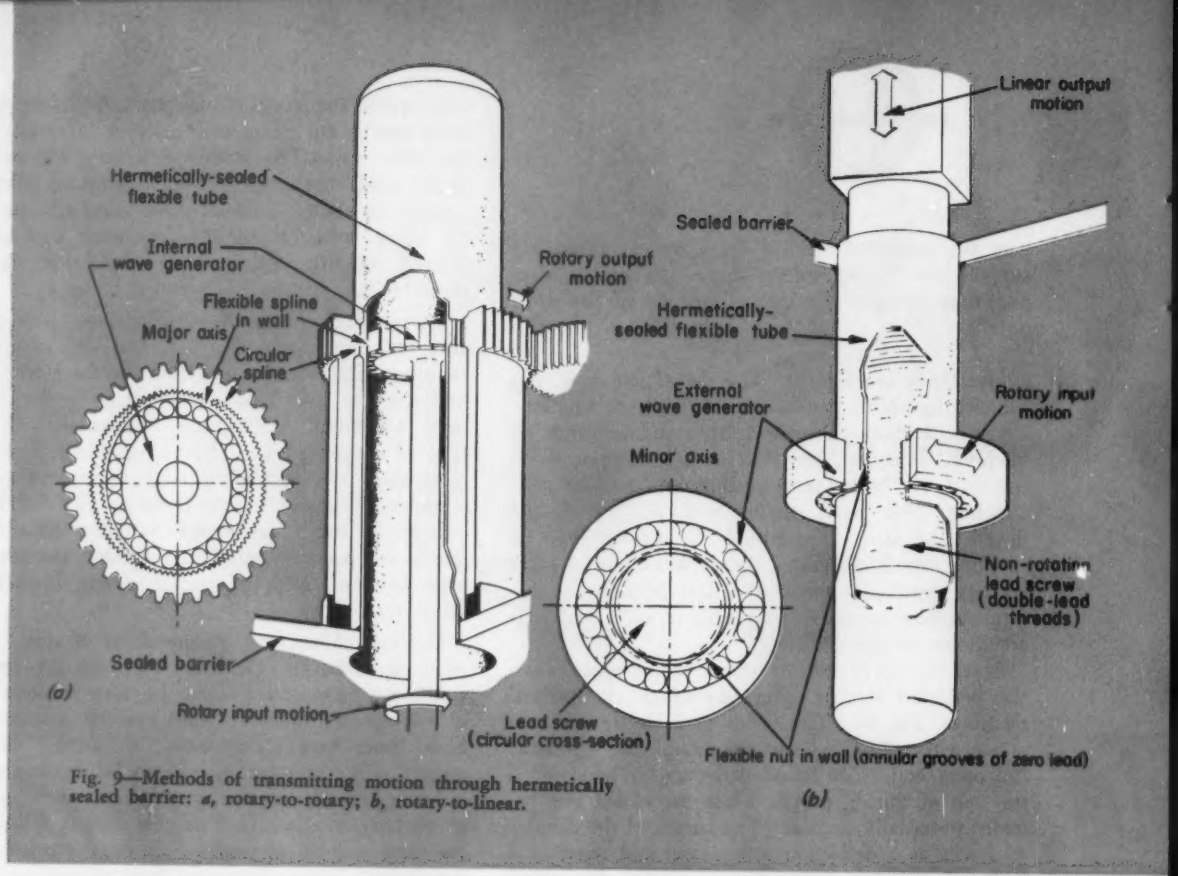


Fig. 9—Methods of transmitting motion through hermetically sealed barrier: *a*, rotary-to-rotary; *b*, rotary-to-linear.

basic drive unit has an internal elliptoidal-cam wave generator, a flexible spline with integral coupling to the output shaft, and a circular spline machined in the supporting case. While the drive is shown as a speed reducer, it can be used equally well as a speed increaser by interchanging the functions of input and output shafts.

Single-stage systems can be used in several ways as shown in Fig. 4. Range of application of this new type of mechanical system is further extended when drive stages are combined to form multiple-stage systems. By combination of internal and external wave generators, flexible splines with multiple sets of teeth, and internal or external circular splines, an almost limitless number of useful mechanical arrangements can be derived. Typical compound and dual systems are shown in Fig. 8.

COMPOUND DRIVE: Drive stages can be compounded radially or axially. In the radial arrangement, Fig. 8*a*, the input wave generator (the innermost element) drives the first-stage circular spline with 100:1 speed reduction. The flexible spline for this stage is rotationally fixed to the supporting case.

The first-stage circular spline forms the input

Fig. 10—External volume versus output torque. Plot is representative of systems with 100:1 drive ratio. Band of values indicates practical design range from 25 to 50 lb-in. per cu in.

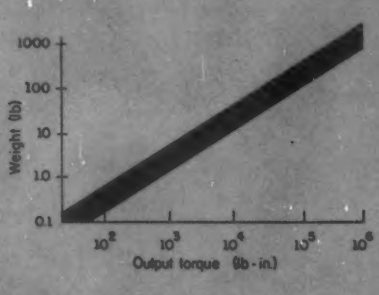


Fig. 11—Weight versus output torque. Band is representative of 100:1 ratio drive systems. Range of practical design can vary from 150 to 500 lb-in. per lb.

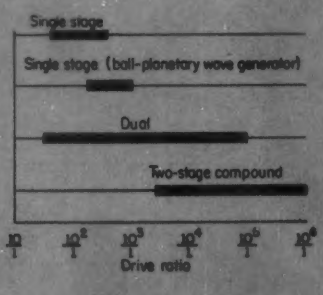


Fig. 12—Ranges of preferred drive ratios for four drive configurations. Plot shows general ranges possible with steel flexible splines in units of moderate physical size.

wave generator of the second stage. The flexible spline of this stage is also held stationary and the second-stage circular spline provides the output motion of the two compounded stages. If the second stage provides a 150:1 reduction, the total ratio from first-stage input to second-stage output is 15,000:1.

An axial-compound drive is produced when the circular splines are anchored, Fig. 8*b*, and the first-stage flexible spline drives the second-stage wave generator. With ratios calculated on the basis of the flexible spline motion, the drive shown produces an over-all reduction of 12,500:1. Other forms of compound drives can also be built up, and ratios of 1,000,000:1 can be achieved with only two compounded stages.

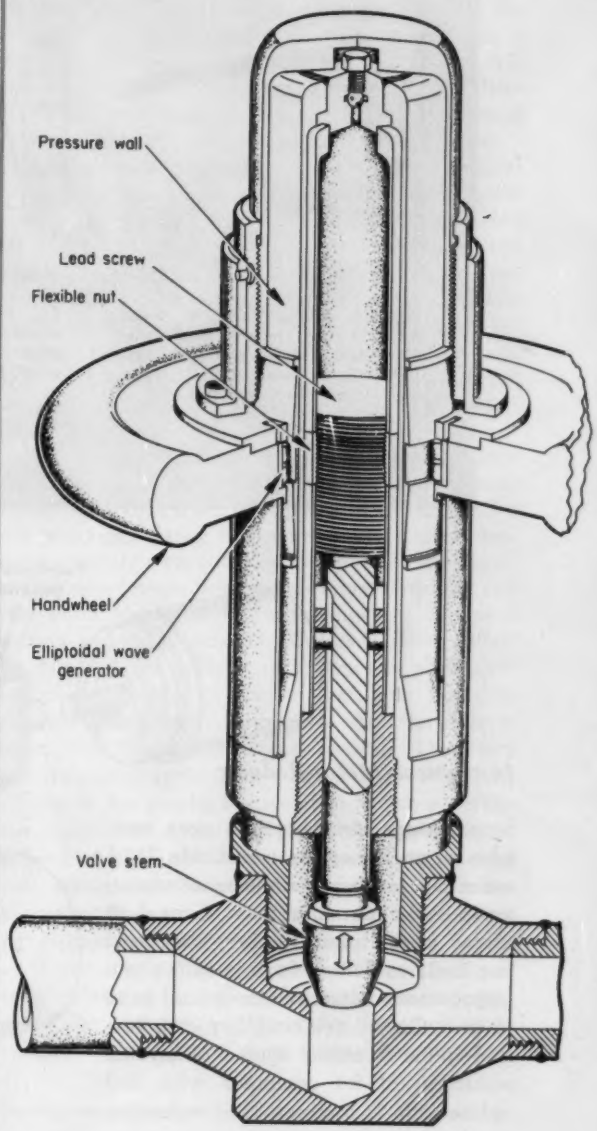
DUAL DRIVE: The term "dual" defines systems in which one or more of the principal elements serve two separate sets of engaging splines. In Fig. 8c, for example, a single flexing member carries two sets of spline teeth, and a single elliptoidal wave generator causes these two flexible splines to engage separate circular splines at the major axis.

The high-ratio dual drive shown has one spline engagement between a flexible spline and a stationary circular spline. Another spline engagement occurs between a second flexible spline and an external circular spline which produces the output rotation. As the wave generator is rotated, the two sets of splines produce rotations in opposite directions to develop a differential action. The two sets of splines have separate ratios of 101:1 and 100:1. In combination, they produce an over-all dual reduction of 5050:1.

A form of intermediate-ratio dual drive results if the output circular spline engages the flexing member internally at regions on the minor axis of the elliptoid. The additive action of the two resulting sets of splines produces a dual reduction ratio of about one-half that of a conventional single-stage system.

Sealed Drive Systems: A unique and useful characteristic of this type of drive system is its ability to transmit mechanical motion through sealed walls, Fig. 9. The wall can be part of a welded steel enclosure which is capable of maintaining complete isolation of two environments.

ROTARY-TO-ROTARY DRIVE: Use of the standard rotary-to-rotary arrangement for positive drive through a hermetic seal is shown in Fig. 9*a*. Here the flexible spline teeth are placed near the center of a sealed cylindrical tube. The internal elliptoidal wave generator deflects the tube so that the flexible and circular splines engage at two regions on the major axis of the elliptoid. Since the numbers of teeth on the flexible and circular splines differ, rotation of the wave generator causes a reduced rotation of the output circular spline. With this



Rotary-to-Linear Valve Actuator

Modified drive system for conversion of rotary-to-linear motion is used to actuate sealed valve-stem assembly. Hand wheel rotates wave generator which transmits elliptoidal shape through sealed pressure wall to flexible nut. Lead screw is held from rotating by pins but is free to translate and move valve stem. Since lead screw has double-lead threads, two-lobe wave generator deflects zero-lead flexible nut into engagement on minor axis. As wave generator rotates, regions of thread engagement advance around periphery of lead screw, producing translation of screw and valve stem.

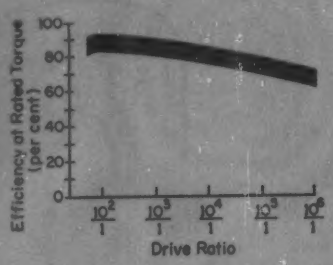


Fig. 13—Efficiency versus drive ratio. Values apply to steel flexible splines with integral couplings, and include losses of both input and output shaft bearings.

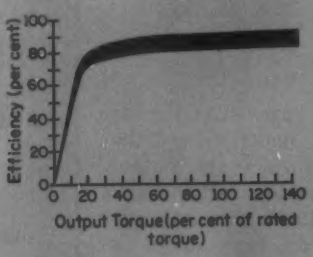


Fig. 14—Efficiency versus output torque. Plot applies to single-stage drive system with integral coupling to flexible spline.

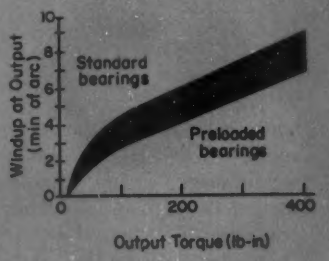
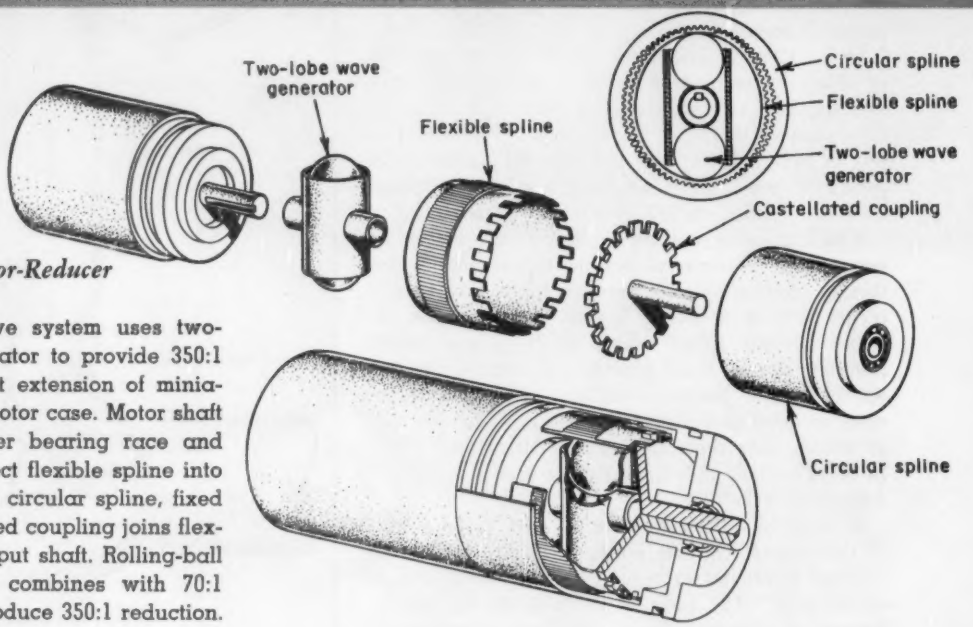


Fig. 15—Windup versus output torque. Plotted values are based on a specific unit with 172:1 reduction ratio, 380 lb-in. rated output torque and 3-in. diam splines. With input clamped, windup angle at output is shown as a function of torque applied at the output.

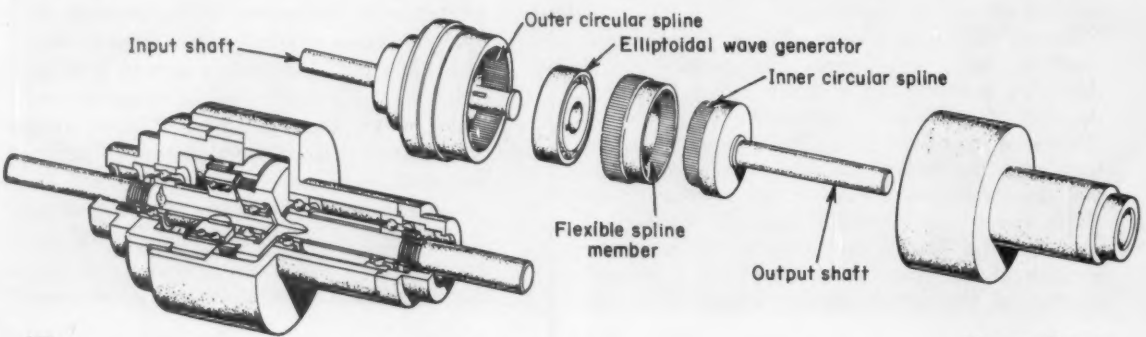


Instrument Motor-Reducer

Single stage drive system uses two-lobe wave generator to provide 350:1 reduction in short extension of miniature instrument motor case. Motor shaft drives small inner bearing race and two balls to deflect flexible spline into engagement with circular spline, fixed to case. Castellated coupling joins flexible spline to output shaft. Rolling-ball reduction of 5:1 combines with 70:1 spline ratio to produce 350:1 reduction.

Intermediate-Ratio Dual-Reduction Drive

Dual-reduction drive system employs single wave generator to produce tooth engagement at major and minor axes of elliptoid. External flexible spline (124 teeth) engages outer circular spline (126 teeth) and internal flexible spline (116 teeth) engages inner circular spline (114 teeth). Ratios of two sets of splines have same algebraic sign, resulting in an approximate 30:1 reduction.



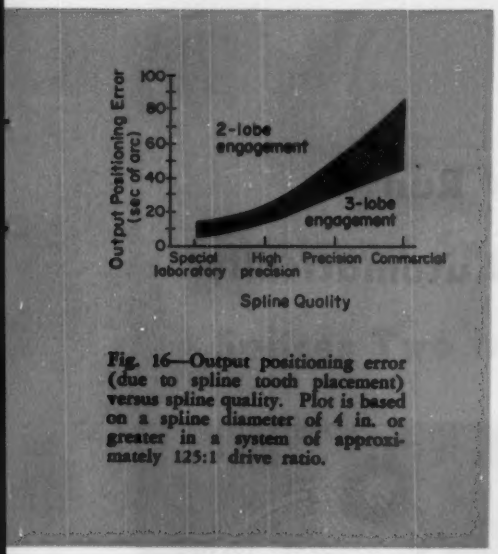


Fig. 16—Output positioning error (due to spline tooth placement) versus spline quality. Plot is based on a spline diameter of 4 in. or greater in a system of approximately 125:1 drive ratio.

system, rotary motions can be generated within a completely sealed vessel.

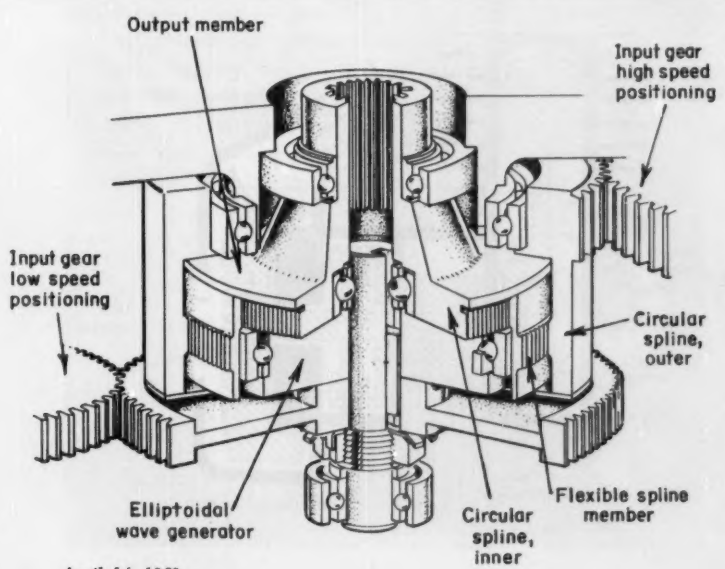
ROTARY-TO-LINEAR DRIVE: The method of rotary-to-linear transmission of motion through a hermetically-sealed wall represents a departure from the standard drive arrangement. Fig. 9*b* shows a sealed pressure envelope with flexible cylindrical walls surrounding a translatory, but nonrotating, lead screw with a circular cross section. The inner wall of the flexible tube has annular grooves (threads of zero lead) and forms a flexible nut. The external wave generator, operating through antifriction bearings, forms the flexible nut into an elliptoidal shape and deflects it into engagement with the lead screw at two diametrically opposite regions on the minor axis of the elliptoid.

To permit such engagement, lead-screw threads must advance one full thread per half revolution. That is, they must be double-lead threads. The general relationship for engagement of the flexible nut and lead screw is that the two have a difference in lead equal to, or an integral multiple of, the number of lobes on the wave generator. Thus, a two-lobe system can operate with a zero-lead nut and a double-lead screw as shown, Fig. 9*b*. Alternatively, the system can operate with a single-lead right-hand nut and a single-lead left-hand screw.

As the wave generator is rotated, the elliptoidal shape is advanced around the wall of the flexible tube. The flexible nut itself does not rotate but its elliptoidal shape does, causing the minor-axis regions of engagement to progress around the lead screw and produce translation of the screw. The direction of linear motion can be reversed by reversing the direction of wave-generator rotation. Linear actuators of high mechanical advantage can be made using this rotary-to-linear configuration.

Performance Capabilities: Plotted performance curves, Fig. 10 through 16, are based on operational tests conducted on apparatus developed for the prolonged testing of rotary-to-rotary drives under accurately controlled load conditions. Independent measurements were made simultaneously on two drive units, tested interchangeably as speed reducer and speed increaser. Units have been driven for hundreds of millions of cycles, and their performance measured to better than one per cent accuracy. Additional comparative data have been taken from systems developed for special military and industrial applications.

Each of the graphs focuses attention on a particular physical or operational-performance parameter. A band of values is shown in most plots, ranging from conditions of standard design and manufacture to conditions of custom design and more exacting methods of manufacture. These broad curves are drawn about "design center" values which are conservatively achievable today with standard systems. The design of any particular drive unit must represent a balancing of these various parameters.

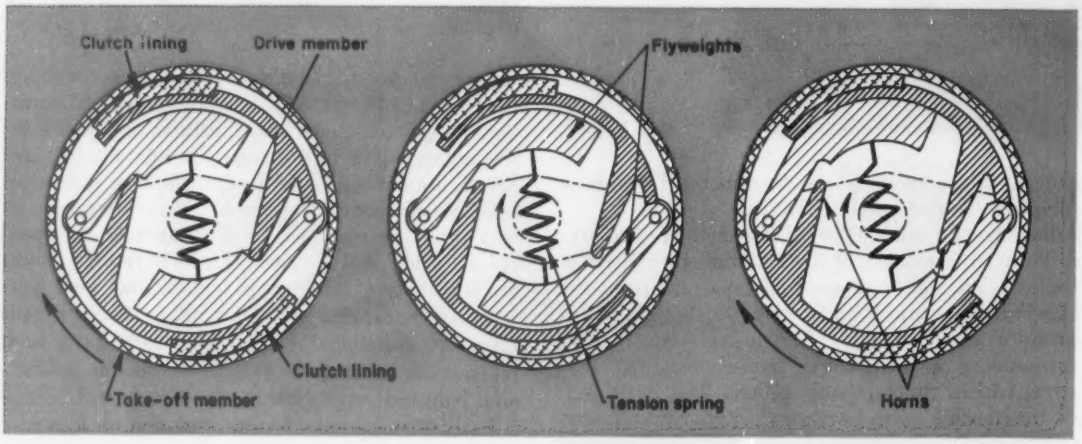


Fine-Coarse Control Drive

Independent low-speed and high-speed positioning controls are achieved in dual-stage drive system. Input gear at left drives elliptoidal wave generator which deflects flexible spline member. External spline engages outer circular spline at major axis; internal spline engages inner circular spline at minor axis. Through dual action, input rotation is reduced by 30:1 in assembly. For fast positioning, input rotation is introduced at outer circular spline with gear at right. Slight speed increase is produced through dual-stage action of splines.

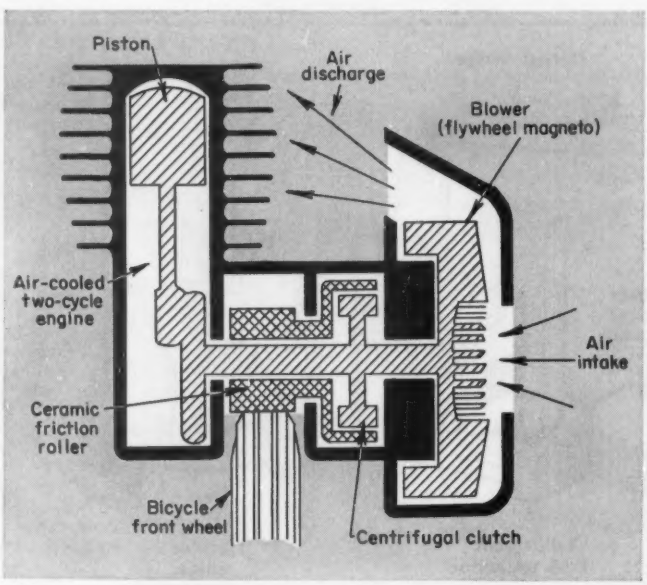
• Start • Idle • Run

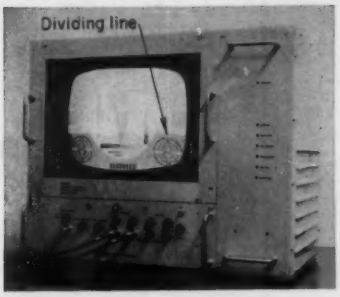
Three-position Clutch Does It Automatically



FRICTION CLUTCH ENGAGES either at running speeds or stopped, but disengages when motor is idling. Used on a bicycle front-wheel motor, the clutch enables a cyclist to start his motor by pedaling, but permits the bicycle to stand with the motor idling. In starting position, flyweights, unaffected by centrifugal force, are drawn together by a tension spring until they contact horns on the clutch shoes and push the shoes into contact with the drum. Idling motor pulls weights free of horns. At running speed, centrifugal clutch operates typically.

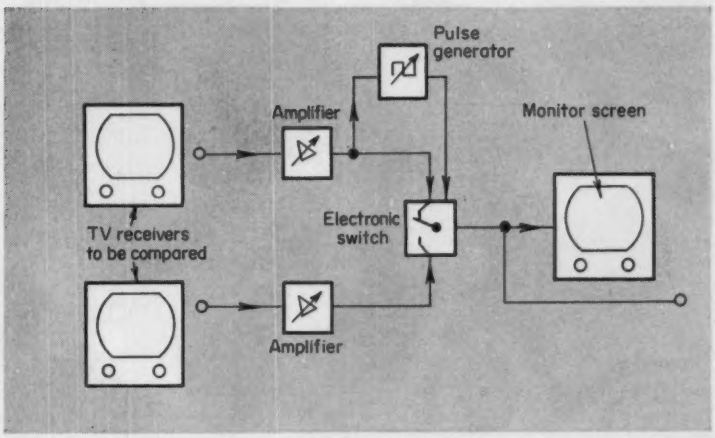
FLYWHEEL MAGNETO BALANCES air-cooled power cylinder on the bicycle. It doubles as a blower to direct cool air against the cylinder fins. Piston displacement is 3 cu in. Motor develops 0.6 hp at top speed of 20 mph. Bicycle and motor designed and manufactured by Velo-Solex, Courbevoie, France, weigh 62 lb.





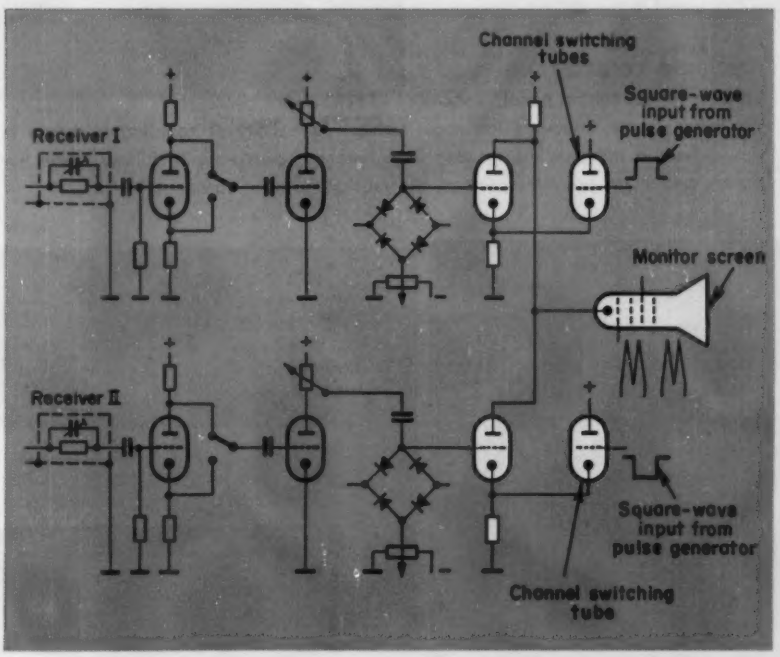
Visual comparator for black-and-white or color television sets was developed by Telefunken GmbH, Berlin, Germany.

Electronic Switch Splices Two Inputs For Side-by-Side Comparison of Image Quality



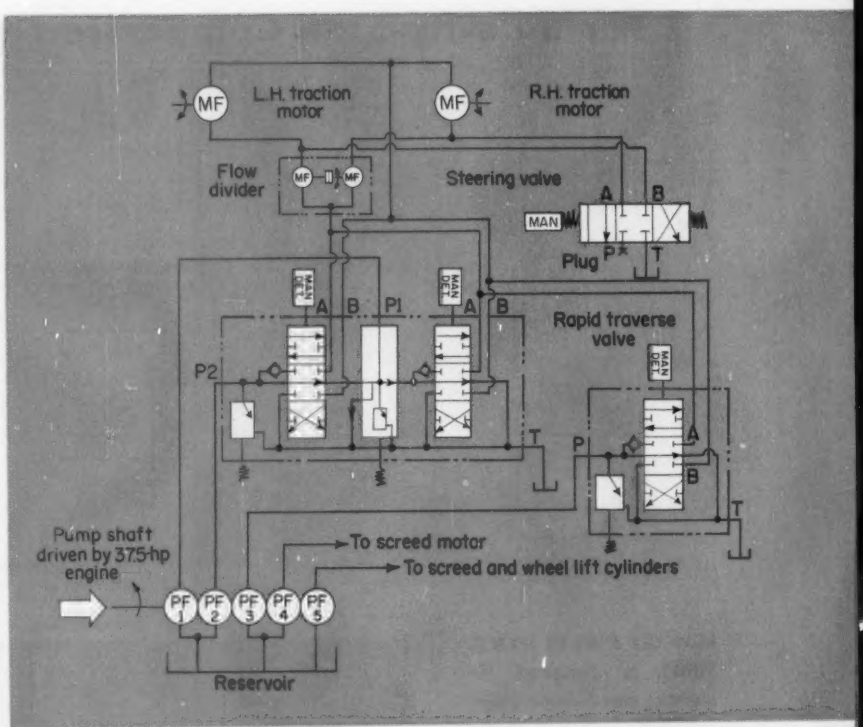
TO COMPARE RECEPTION of two television receivers, their signals are fed to a synchronized selector that switches from one to the other at a predetermined point in the scanning cycle. Thus, upper half of a picture received on a monitor screen is from one TV receiver; bottom half is from the other. Switch is synchronized by output to pulse generator from one of the receivers being tested.

BIAS ON SWITCHING TUBES is produced by square wave from pulse generator. This gives instantaneous response and cut-off, phased exactly 180 degrees apart for the two tubes. Switch operates by pre-empting current from power amplifier when it's unblocked. Rest of circuit consists of phase-inverters and preamplifiers with brightness and contrast controls.

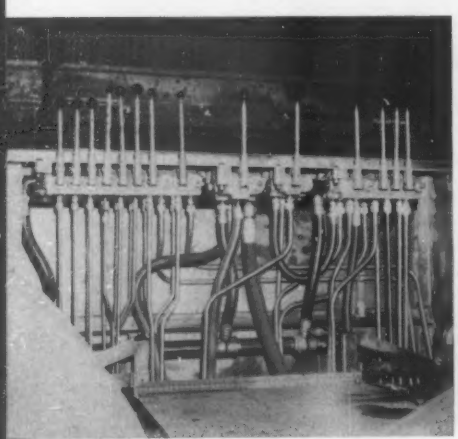


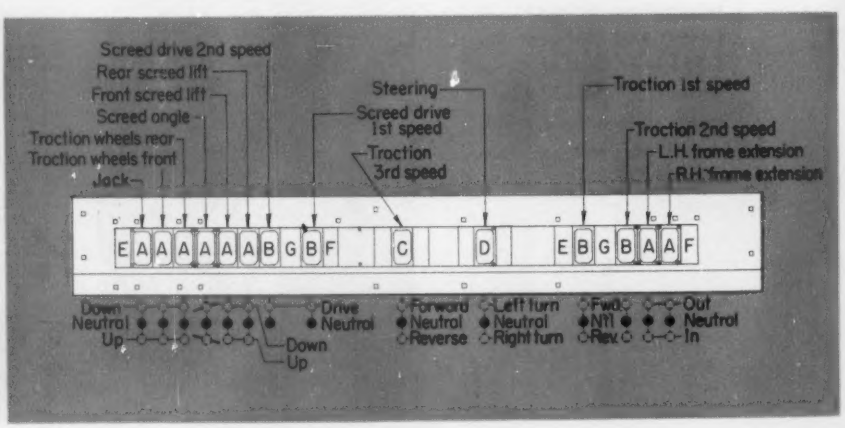
Road Spreader Shifts Speed By Selecting

VARYING RATES OF SPEED are achieved by juggling inputs from three fluid pumps in a hydraulic road spreader. Fluid power is supplied by five pumps of varying capacity mounted on a single shaft and driven by a 37.5-hp engine. Pumps 1 and 2 can be used singly or in combination to produce speeds of 11, 16, or 28 fpm. Output of pump 3, normally used to operate mixing screws, can be added to produce a top speed of 80 fpm. Fluid output to traction motors is balanced by a fluid divider consisting of two small hydraulic motors. These are coupled and must turn at the same speed, metering the fuel evenly between traction motors. Steering is done with a bypass valve that "short-circuits" supply to one motor, producing unequal effort from the two motors.



OPERATING CONTROLS ARE LINED up on a central control panel. Rocking levers locate three-position spool valves. Simplicity of coupling is shown in back view where a minimum of crossing lines makes circuits easy to follow. Five hydraulic motors and eight cylinders perform the machine's many functions.



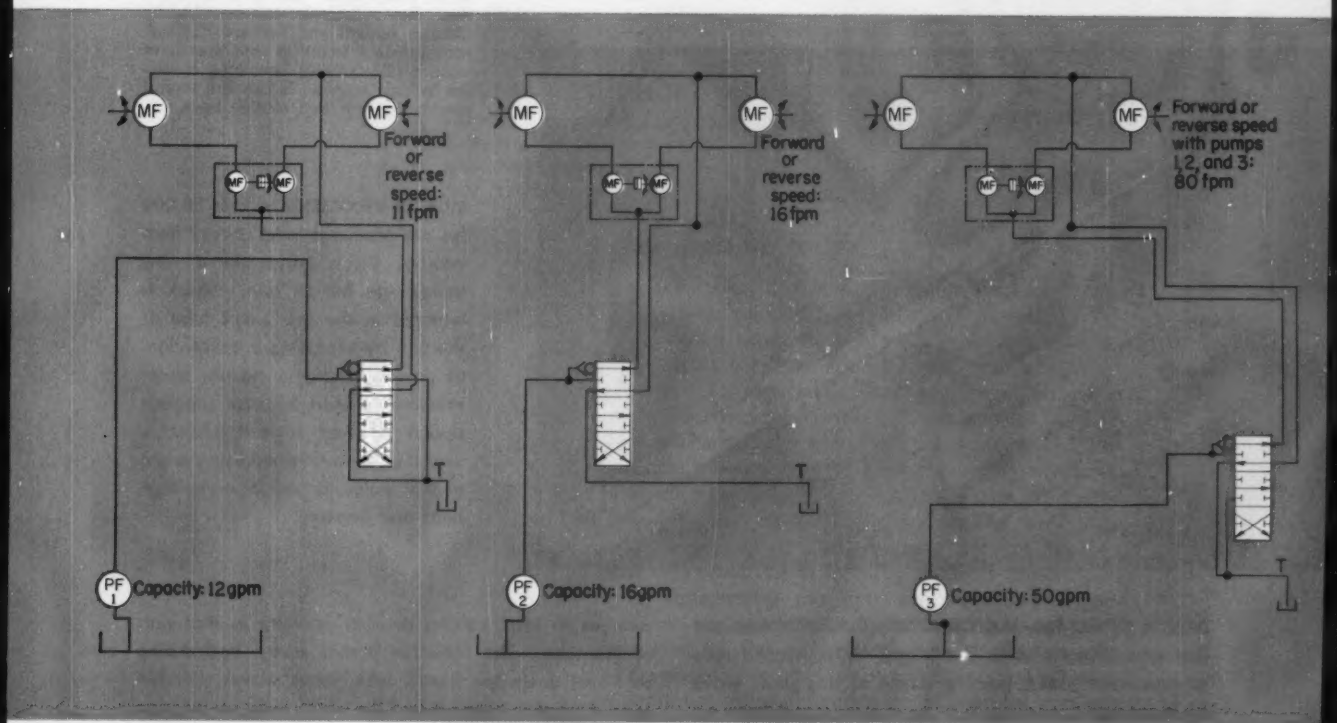


Outputs from:

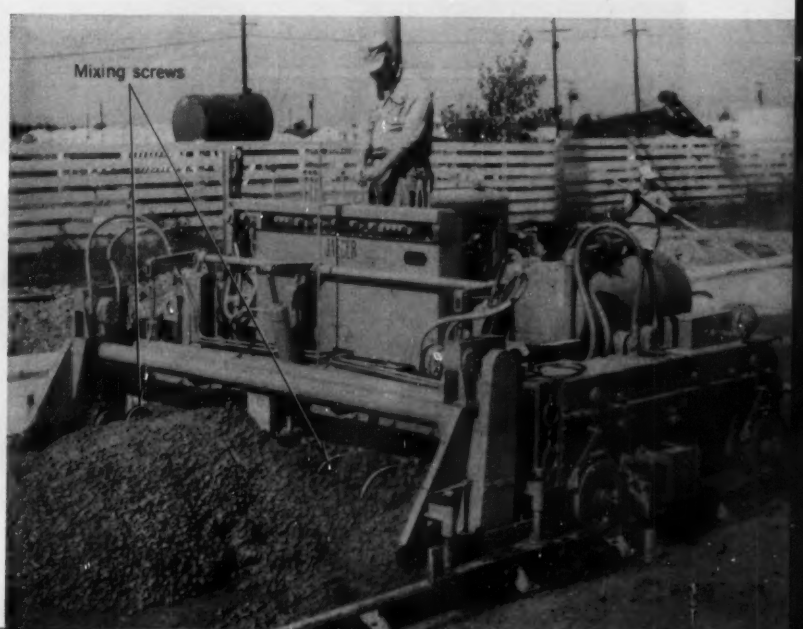
One pump (PF 1) = 11 fpm

Two pumps (PF 1 + PF 2) = 28 fpm

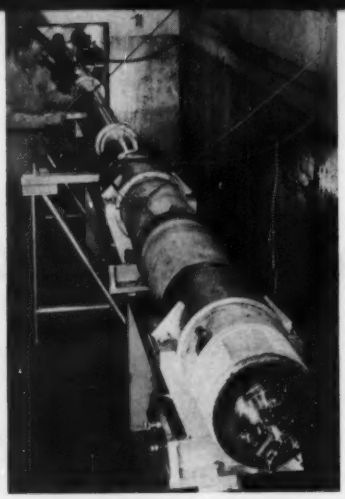
Three pumps (PF 1 + PF 2 + PF 3) = 80 fpm


MF
Forward or reverse speed: 11 fpm
PF 1 Capacity: 12 gpm
Forward or reverse speed: 16 fpm
PF 2 Capacity: 16 gpm
Forward or reverse speed with pumps 1, 2, and 3: 80 fpm
PF 3 Capacity: 50 gpm
T

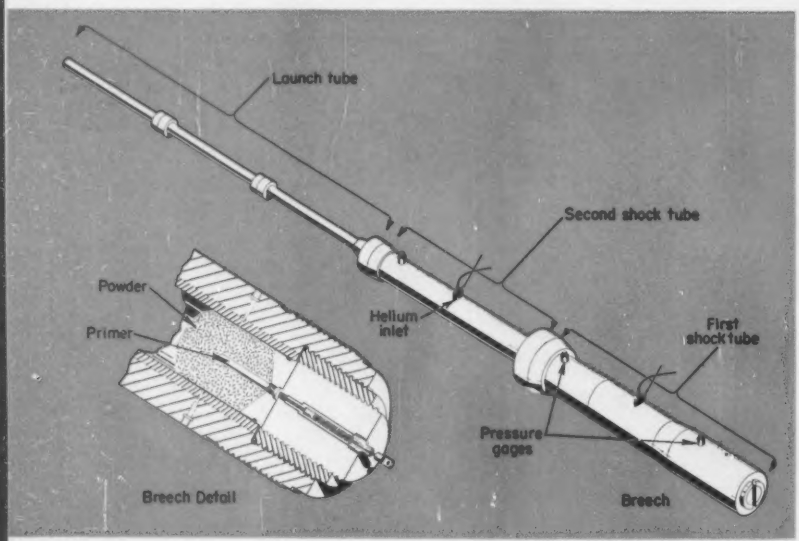
FLANGED WHEELS RIDE ON FORMS for concrete on the first pass. After one strip is laid, they can use the finished concrete strip as a rail on one side. Telescoping trusses permit the whole frame to extend sideways from a minimum width of 12 ft to a maximum width of 18 ft. Hydraulically driven screws thoroughly mix the concrete and break up pockets. This action packs concrete against sides and bottom of cavity for a uniform, high-density slab. Spreader was built by Jaeger Machine Co., Columbus, Ohio. Hydraulic components to it were furnished by Commercial Shearing and Stamping Co., Youngstown, Ohio.



Shockwaves Launch Supersonic Projectiles From Three-Stage Helium Gas Gun

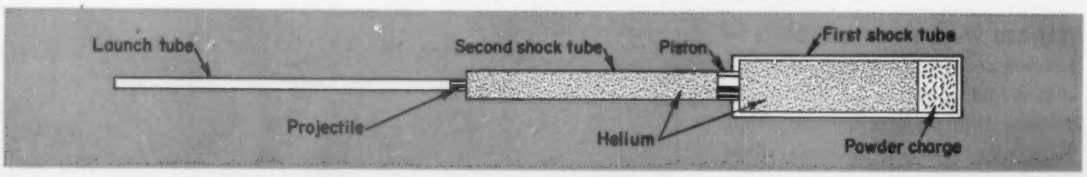


Shock-compression gas gun, built at Ames Research Center and described by Carlton Bioletti and Bernard E. Cunningham in a technical note, may have wide applications in launching models on ballistic ranges. It can fire several rounds per day on a routine basis.

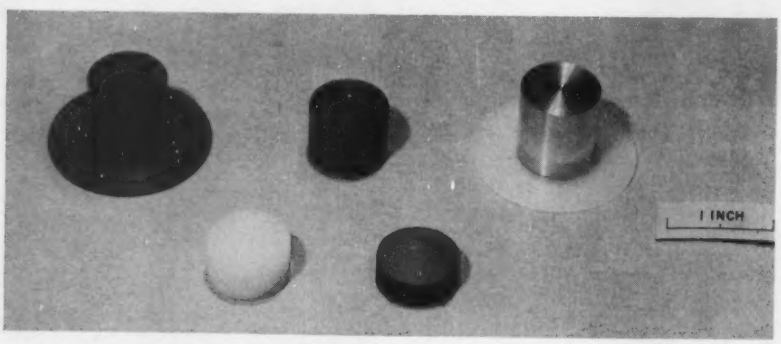


MUZZLE VELOCITIES of over 20,000 fps are produced using energy from internal shock waves in a new three-stage helium gun. Shock is initiated in the first shock tube of the gun by exploding a conventional powder charge. Helium under pressure is used because previous studies showed highest projectile velocities were attained using a gas of low molecular weight under high heat and pressure.

DRIVEN BY HEATED AND COMPRESSED HELIUM from the first tube, piston travels the length of the second tube at supersonic speed, pushing ahead of it a shock wave of increasing intensity. This wave is reflected from the closed end of the tube. Restrained kinetic energy changes to heat, raising the gas pressure in that part of the tube. The projectile breaks away, and during its travel down the launch tube, shock waves reflected several times between it and the piston keep up pressure of the helium behind it for added acceleration.



PROJECTILE IS HELD by a shear disc which fails when pressure is built to sufficiently high level by the shock wave. Projectiles up to 20 mm diam and weighing up to 130 gm have been launched from the gun at more than Mach 20 in simulating re-entry problems.



Combination of Subsystems

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PROCEDURES given earlier for vibration analysis of lumped multiple-mass systems[4] can be readily extended to systems with any number of degrees of freedom. Either "inline" or "branched" arrangements can be handled with equal effectiveness. The amount of work increases rapidly as more mass elements are added to the system, but the basic method is the same. One rule of recommended practice with complex systems deserves emphasis. The schematic mobility diagram should be drawn before equations are set up for either the component or normal-mode mobility methods of analysis.

To demonstrate this approach, certain problems that are representative of situations commonly encountered in the analysis of complex systems can be examined. Methods for handling coupled systems, determining natural frequencies of complex systems,

[4]References are tabulated at end of article.

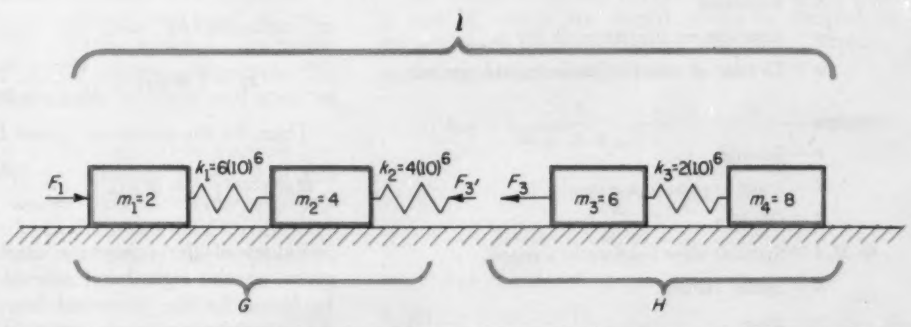

Fig. 24—Method of analyzing a coupled system, *I*, formed by joining two simple systems, *G* and *H*, whose response values are known.

and evaluating the effect of support flexibility on natural frequency will be presented.

Coupled Systems

A common problem in vibration analysis is to predict the response of a system formed by coupling two simpler systems together. This problem has been investigated by others. Tables have been formulated to reduce the time required to set up a problem and to minimize the possibility of computational errors.[5]

The method of handling coupled systems will be illustrated with an example. Such a system is shown in Fig. 24. System G could represent a prime mover and system H a driven machine. Characteristics of the driven machine can vary from one application to the next. If the displacement mobilities (M_{D11G}, $M_{D13'G}$, and $M_{D3'3'G}$) of the prime mover are known, the single mobility (M_{D33H}) of any driven machine that might be used could easily be obtained, either analytically or experimentally. This mobility value can then be used to predict the driving-point response of any driven machine. The analysis could also be extended to find the transfer response at other points in the combined system.

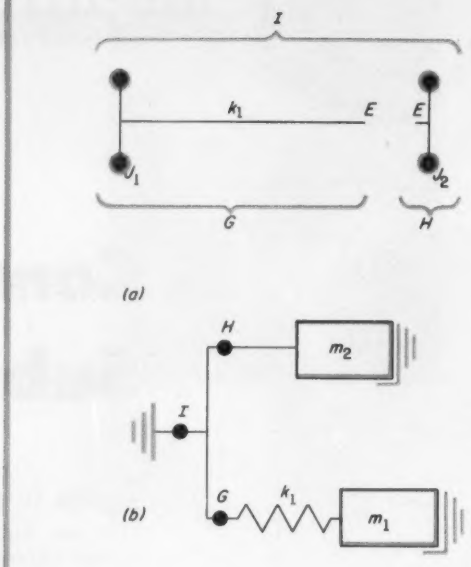

Fig. 25—Two-disc, single-shaft system showing, *a*, division of main system into subsystems, and, *b*, schematic mobility diagram for determining system natural frequencies by impedance matching.

Example 1: Systems G and H, Fig. 24, are to be joined into single system I. Determine the driving-point mobility of the combination at mass m_1 for an excitation of 1000 rad per sec.

Solution will be obtained on a displacement-mobility basis. In Fig. 24, the internal forces acting at the juncture of systems G and H are $F_{3'}$ and F_3, respectively. Displacement of system G at the juncture is

$$x_{3'} = M_{D3'1G} F_1 + M_{D3'3'G} F_{3'}$$

Displacement of system H at the same point is

$$x_3 = M_{D33H} F_3$$

At the juncture, $x_3 = x_{3'}$. Therefore,

$$M_{D33H} F_3 = M_{D3'1G} F_1 + M_{D3'3'G} F_{3'}$$

Also, at the juncture, $F_{3'} + F_3 = 0$. Substituting $-F_3$ for $F_{3'}$ in the preceding equation and solving for F_3,

$$F_3 = \left(\frac{M_{D3'1G}}{M_{D33H} + M_{D3'3'G}} \right) F_1$$

At mass m_1, amplitude x_1 is

$$x_1 = M_{D11G} F_1 + M_{D13'G} F_{3'}$$

or, replacing $F_{3'}$ with the negative value of F_3,

$$x_1 = \left(M_{D11G} - \frac{M_{D13'G} M_{D3'1G}}{M_{D33H} + M_{D3'3'G}} \right) F_1$$

Then, for the combined system I,

$$M_{D11I} = \frac{x_1}{F_1} = M_{D11G} - \frac{(M_{D13'G})^2}{M_{D33H} + M_{D3'3'G}} \qquad (75)$$

Values of the subsystem displacement mobilities given on the right-hand side of Equation 75 may be found for the impressed frequency by following the principles previously outlined[4] or by using Holzer tables. For component values given in Fig. 24 and impressed frequency $\omega = 1000$ rad per sec, these

Nomenclature

F = Force, lb
k = Spring gradient or rate, lb per in.
M_D = Displacement mobility, in. per lb
m = Mass, lb-sec² per in.
x = Linear displacement, in.
Z = Impedance
Z_D = Displacement impedance, lb per in.
ω = Circular or angular frequency, rad per sec

Subscripts

b = Bearing
E = Point location in a system
f = Oil film
G, H, I = Systems; point locations in a system
k = Spring element
m = Mass
r = Rotor

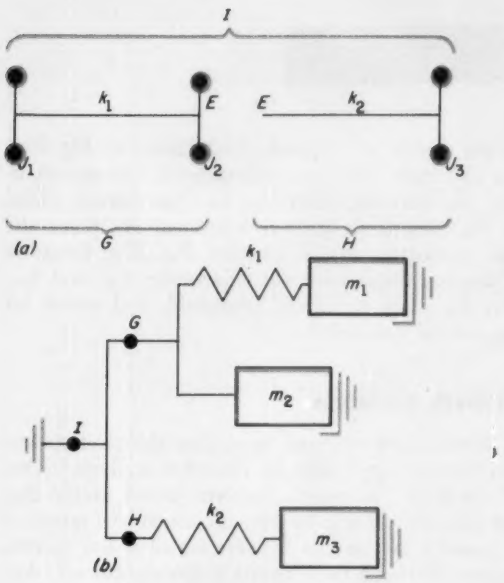

Fig. 26—Subdivision of three-disc, two-shaft system for finding system natural frequencies by impedance matching. Subsystem *G* is actually the complete system of Fig. 25*a*. Schematic mobility diagram, *b*, aids in setting up the impedance equations.

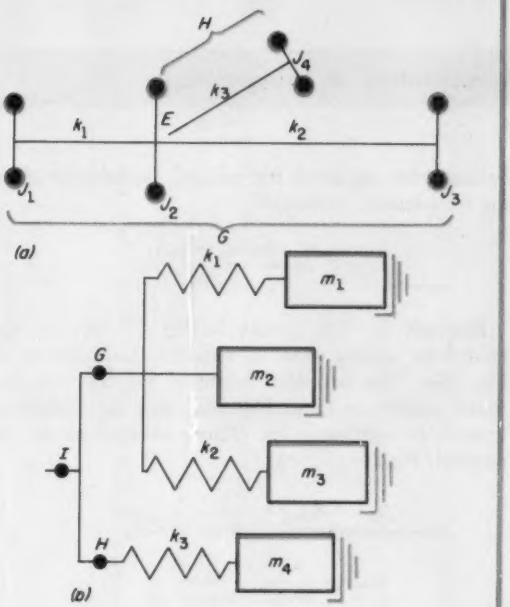

Fig. 27—Method of subdividing branched system to determine natural frequencies of total system. Subsystem *G* is actually the complete system of Fig. 26*a*. Schematic mobility diagram, *b*, facilitates analysis and understanding of the complex relationships involved.

mobility values are:

$$M_{D11G} = -\,0.07167\,(10)^{-6} \text{ in. per lb}$$

$$M_{D13'G} = 0.2142\,(10)^{-6} \text{ in. per lb}$$

$$M_{D33H} = 0.1071\,(10)^{-6} \text{ in. per lb}$$

$$M_{D3'3'G} = 0.3\,(10)^{-6} \text{ in. per lb}$$

Substituting these values into Equation 75 gives the displacement mobility for the combined system:

$$M_{D11I} = 0.1667\,(10)^{-6} \text{ in. per lb}$$

The same procedure can be used to analyze systems of any complexity.

Impedance Matching

If expressions are developed for the driving-point and transfer mobility functions in any system, they all will be found to have the same denominator.[6,7] When this denominator equals zero, response is infinite. If the denominator is set equal to zero, the resulting equation may be solved to determine natural frequencies of the system. However, this expression can become quite involved and may be laborious to solve.

A second method of finding system natural frequencies is to divide the complete system into two subsystems which act in parallel. This approach is the inverse procedure of the one used in the preceding section. When the sum of the impedances at the juncture equals zero,

$$Z_I = Z_G + Z_H = 0 \qquad (76)$$

For this condition, impedances Z_G and Z_H are said to be "matched," and resonance will result. While this procedure generally yields results, there is a possibility that no force is transmitted through the juncture of the subsystems. In that event, each subsystem vibrates independently of the other at a particular frequency. Such a situation is not common except where the subsystems are symmetrical about the juncture.

The concept of matching impedances is a very useful tool, particularly in the design of vibration isolators. An example of this procedure is described in Reference 8 for crankshaft and flywheel combinations. The method of matching impedances to determine natural frequencies of complex systems will be demonstrated here with three examples.

Example 2: Consider the two-disc, single-shaft system shown in Fig. 25. Although the natural frequencies are well known, they will be determined here using the method of impedance matching.

The complete system, *I*, is divided into subsystems *G* and *H*, which are shown acting in parallel in the schematic mobility diagram, Fig. 25*b*. Displacement impedances of subsystems *G* and *H* are:

$$Z_{DG} = \frac{1}{M_{Dk1} + M_{Dm1}} = \frac{1}{\dfrac{1}{k_1} - \dfrac{1}{m_1\omega^2}}$$

$$= \frac{k_1 m_1 \omega^2}{m_1 \omega^2 - k_1}$$

$$Z_{DH} = -\,m_2\,\omega^2$$

Applying Equation 76,

$$Z_{DI} = Z_{DG} + Z_{DH} = \frac{k_1 m_1 \omega^2}{m_1 \omega^2 - k_1} - m_2 \omega^2 = 0$$

Solving this equation for natural frequencies gives the well-known expression,

$$\omega^2 = 0, \text{ or } \frac{k_1(m_1 + m_2)}{m_1 m_2}$$

Example 3: The system in Fig. 25 may be extended by adding shaft k_2 and disc J_3 as shown in Fig. 26*a*. The two-disc system of Fig. 25 now becomes subsystem *G* in Fig. 26*a*, and the additional branch is subsystem *H*. These subsystems act in parallel, Fig 26*b*. Then,

$$Z_{DG} = Z_{Dm2} + \frac{1}{M_{Dk1} + M_{Dm1}}$$

$$Z_{DH} = \frac{1}{M_{Dk2} + M_{Dm3}}$$

Substituting these expressions into Equation 76,

$$-m_2\omega^2 + \frac{1}{\frac{1}{k_1} - \frac{1}{m_1\omega^2}} + \frac{1}{\frac{1}{k_2} - \frac{1}{m_3\omega^2}} = 0$$

Combining terms,

$$\left(\frac{m_1 m_2 m_3}{k_1 k_2}\right)\omega^4 - \left(\frac{m_1 m_3 + m_2 m_3}{k_2} + \frac{m_1 m_2 + m_1 m_3}{k_1}\right)\omega^2 + (m_1 + m_2 + m_3) = 0$$

Example 4: Use of the impedance-matching concept may be further extended by adding a branch to the system of Example 3 as shown in Fig. 27*a*. For this new branched arrangement, the system in Fig. 26*a* becomes subsystem *G*. The branch added in Fig. 27*a* is designated subsystem *H*. Since the two subsystems act in parallel, Fig. 27*b*, Equation 76 applies. Expressions for impedances Z_{DG} and Z_{DH} may be found as before, combined, and solved for the natural frequencies.

Network Theorems

Several theorems used to analyze electrical circuits are directly applicable to vibration analysis.[8] One of these is Thevenin's theorem which states that the effect of adding an element across two points of a complex system can be determined if the relative velocity between these points is already known. Another is Norton's theorem which can be used to determine the effect of inserting a component in a branch of a complex system if the force acting in the branch is known.

Since detailed information on the theorems for electrical network analysis is readily available,[9,10] the material will not be repeated here. Other related information dealing with problem solution through the use of network concepts is also available in the literature.[11]

Effect of Support Flexibility

A useful application of the impedance-matching concept is concerned with determination of natural

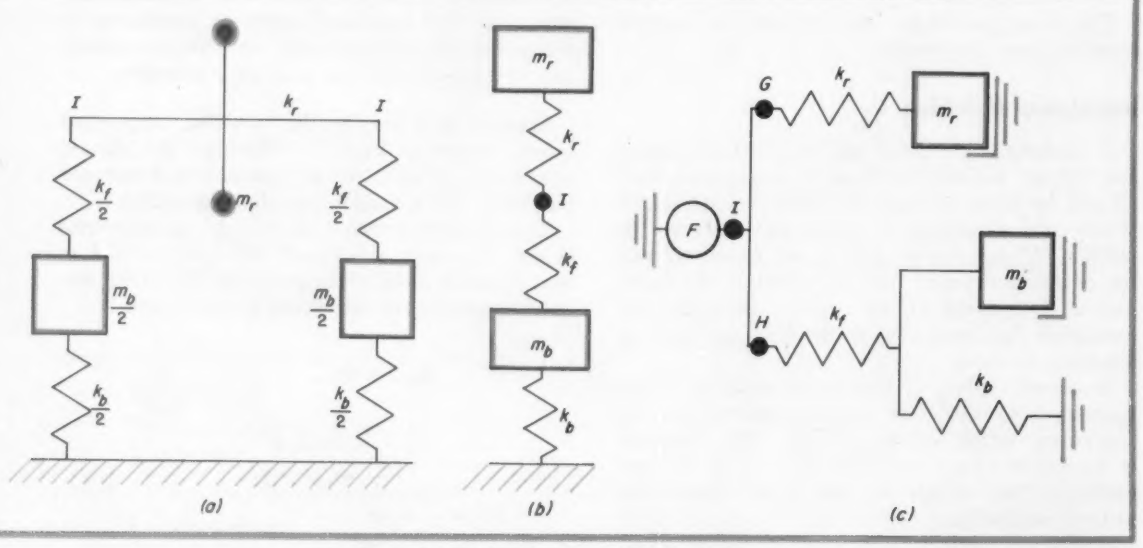

Fig. 28—Effect of flexibility of bearing support and oil film on critical speeds of rotating shaft. Complete system with all factors included is diagramed at *a*. When rocking modes are neglected, complete system reduces to simplified arrangement at *b* where only vertical motion exists. Schematic mobility diagram for the subdivided system in *b* is shown at *c*.

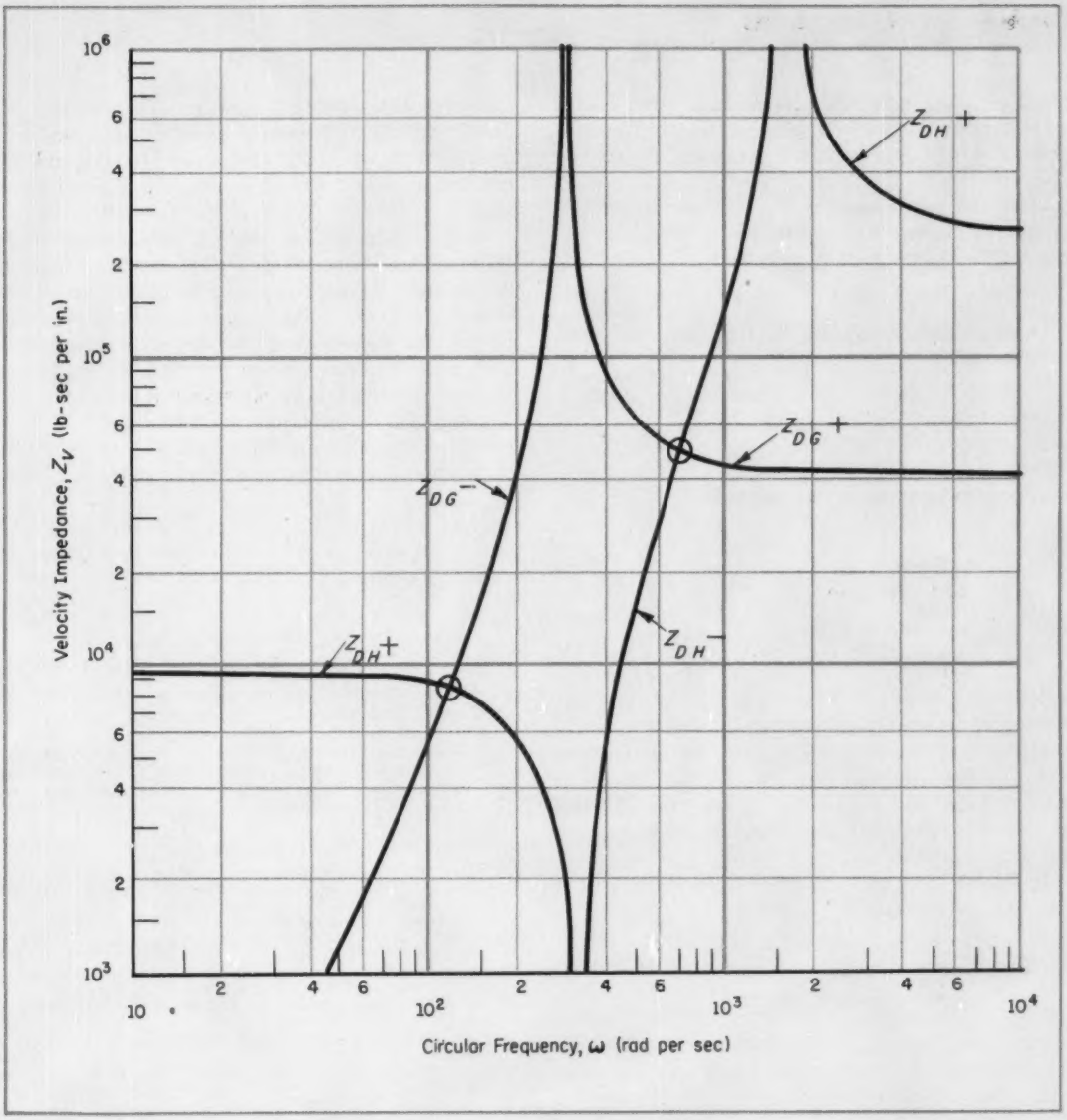

Fig. 29—Displacement-impedance plots for determining critical speeds of rotating shaft in Fig. 28. Resonant frequencies occur at curve intersections.

frequencies or critical speeds of rotating shafts. The usual method of calculating critical speeds is based on the assumption that the supports are rigid and do not deflect. However, the bearing support has mass and flexibility, and the oil film between journal and bearing is also flexible. If these factors are included in the analysis, additional degrees of freedom are introduced into the system and may markedly affect the calculated values of system natural frequencies.

The method for including the influence of the bearing support and oil film in the analysis of natural frequencies will be illustrated with an example.

Example 5: Assume that a single disc of mass m_r is attached to a weightless shaft. Spring gradient of the shaft at the disc is k_r. The shaft is supported on journal bearings with total mass m_b. Oil film spring gradient is k_f. The bearing supports have a spring gradient of k_b. This system is shown diagrammatically in Fig. 28*a*. Given data for the system are: m_r = 193 lb = 0.5 lb-sec² per in.; k_r = 40,000 lb per in.; m_b = 38.6 lb = 0.1 lb-sec² per in.; k_f = 250,000 lb per in.; and k_b = 10,000 lb per in.

To simplify analysis, assume that rocking modes may be neglected and that all motion takes place in a vertical direction. Under these conditions, Fig. 28*a* is reduced to the equivalent system shown in Fig. 28*b*.

Natural frequencies of the complete system, *I*, may be found by dividing it into two subsystems. Subsystem *G* is the shaft and disc combination. Subsystem *H* is the bearing complex, consisting of oil film, bearing mass, and support flexibility. This subdivision is useful for determining, if desired, the

effect of using a different rotor in a given frame, or of putting the rotor in another frame. The subdivided system is represented schematically in Fig. 28c.

Since the subsystems or branches act in parallel, system resonance will occur when impedance of the two branches is matched; that is,

$$Z_G + Z_H = 0$$

Displacement impedance of the shaft and disc, subsystem G, is

$$Z_{DG} = \frac{1}{\frac{1}{k_r} - \frac{1}{m_r \omega^2}} = \frac{20{,}000\,\omega^2}{0.5\,\omega^2 - 40{,}000} \qquad (77)$$

For the bearing complex, subsystem H,

$$Z_{DH} = \frac{1}{\frac{1}{k_f} + \frac{1}{k_b - m_b \omega^2}}$$

$$= \frac{2500(10)^6 - 25{,}000\,\omega^2}{0.26(10)^6 - 0.1\,\omega^2} \qquad (78)$$

Values of Z_{DG} and Z_{DH} are plotted against frequency ω in Fig. 29. Impedance is matched at the points where the curves intersect. At these intersections, the algebraic sum of the two curves is zero, and the entire system is in resonance. In Fig. 29, these intersections correspond to frequencies of 117 and 700 rad per sec.

If the bearings are considered to be rigid, natural frequency of the rotor is

$$\left(\frac{k_r}{m_r}\right)^{1/2} = \left(\frac{40{,}000}{0.5}\right)^{1/2} = 283 \text{ rad per sec}$$

Thus, for the numerical values used in this example, the natural frequencies found with the method that considers support and oil film flexibility are approximately 40 and 250 per cent of the value based on rigid supports. These results indicate why critical speeds found by test are frequently somewhat different than those found by calculations based on the assumption of rigid bearings.[12]

The procedures illustrated in this example could be applied to a standard line of rotating elements and frames. If dynamic properties of each rotor and frame are known, the system natural frequencies for various combinations can be easily determined. The method could also be extended to analysis of natural frequencies in situations involving three-bearing shafts, variation of oil-film stiffness with speed of rotation, distributed mass, and flexibility of the shaft (beam action).

Next article in this series will present principles and methods for analysis of beams and frames as vibrating systems.

REFERENCES

This article is the fifth in a series by Austin H. Church on simplified vibration analysis. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Mobility and Impedance Concepts" .....February 18, 1960
2. "Single-Degree-of-Freedom Systems" .....March 3, 1960
3. "Two-Degree-of-Freedom Systems" .....March 17, 1960
4. "Lumped Multiple-Mass Systems" .....March 31, 1960

Other references in this article are:

5. R. E. D. Bishop—"The Analysis and Synthesis of Vibrating Systems," *Journal of the Royal Aero. Soc.* (British), October, 1954, pp. 703-719.
6. Reference 5, Table I and III.
7. R. E. D. Bishop and D. C. Johnson—*Vibration Analysis Tables*, Cambridge University Press, New York, 1956, Table I and III.
8. *Mechanical Impedance Methods for Mechanical Vibrations*, edited by R. Plunkett, ASME, 1958, pp. 17 and 18.
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10. Ley, Lutz, and Rehberg—*Linear Circuit Analysis*, McGraw-Hill Book Co. Inc., New York, 1959.
11. R. P. Thorn—"The Mobility Method," Part 2, MACHINE DESIGN, Vol. 31, No. 26, December 24, 1959, p. 110.
12. Reference 8, pp. 137-145.

Tips and Techniques

Multiplying Numbers Ending in 5

This easy-to-remember system can be used to rapidly check multiplication of any two numbers that end in 5. Multiplicand and multiplier are represented by A5 and B5 where A and B are any numbers.

To determine "front" part of answer:

1. If A = B, multiply A × B and add A (or B) to the product.
2. If A and B differ by an *even* amount, multiply A × B and add their average to the product.
3. If A and B differ by an *odd* amount, multiply A × B and add the first whole number below their average to the product.

To determine final part of answer:

4. If A and B are both odd or both even, the answer ends in 25.
5. If A and B are mixed (one odd, the other even), the answer ends in 75.

Example 1: Multiply 65 by 45. By rule 2, multiply 6 by 4 and add their average, 5. (6 × 4) + 5 = 29 (front part of answer). By rule 4, the answer ends in 25. Answer is 2925.

Example 2: Multiply 75 by 25. By rule 3, multiply 7 × 2 and add the first whole number below their average, or 4. (7 × 2) + 4 = 18. By rule 5, the answer ends in 75. Answer is 1875. — LESTER BRAGEN, *Schenectady, N. Y.*

Basic Characteristics of

Torque Converters

- *Comparison with Fluid Couplings*
- *Capacity Ratings*
- *Performance Curves*

TORQUE converters are similar to fluid couplings except for the addition of the stator—a stationary reaction member between the impeller and turbine. Functionally, the fluid coupling transmits torque,[1] while the converter additionally provides a torque multiplying feature. In the converter, as shown in Fig. 1, the stator changes the direction of the return flow between the turbine and the impeller. This direction change increases the momentum of the fluid, thereby increasing the torque capacity of the unit. That portion of the total torque which results from the direction change or addition of momentum is called reaction torque.[2]

The amount of reaction torque is determined by the shape, angle, and configuration of the blades. More than one reaction member can be employed. Units are described as single, two, or three-stage converters, in accordance with the number of stages in the turbine. Fig. 2, taken from the *SAE Handbook*, shows a typical three-stage converter with recommended terminology. Maximum torque is transmitted when the turbine is stalled, as in the fluid coupling.

The momentum potential of the impeller of a converter need not be as great as the momentum potential of the impeller of an equivalent-sized coupling, because the converter stator adds momentum to the fluid as it enters the impeller. Therefore, the torque absorption capacity of the converter will not be as great as that of the cou-

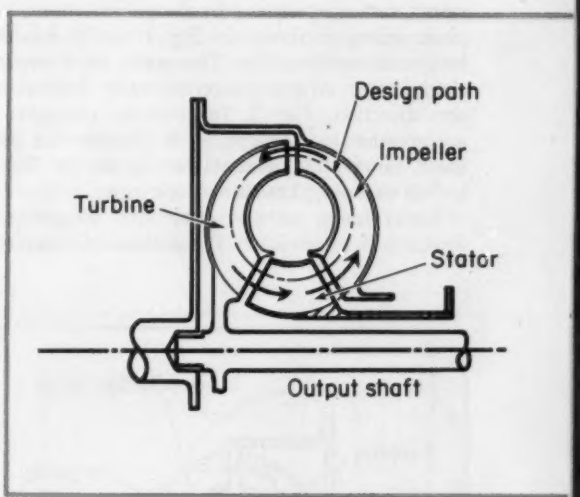

Fig. 1—Single-phase, single-stage torque converter.

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[1]References are tabulated at end of article.

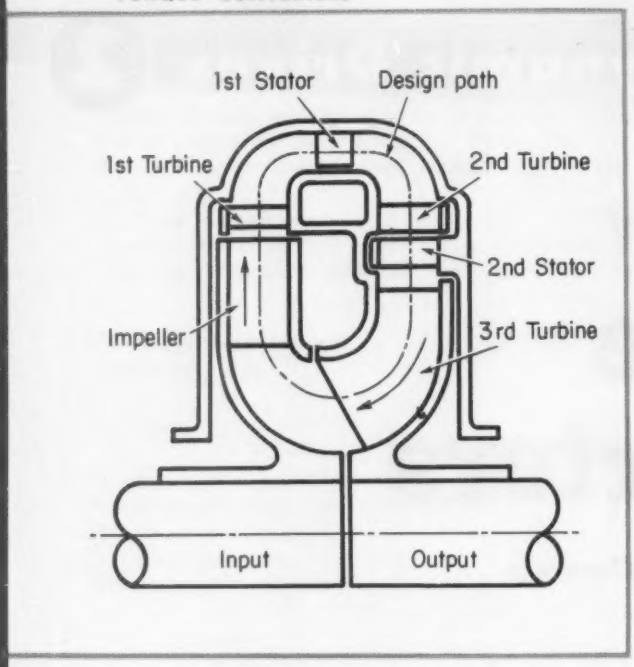

Fig. 2—Single-phase, three-stage torque converter.

pling at a given speed ratio.

A converter may be single, two, or polyphase, depending upon the number of functional arrangements that are provided by design variations. Single-phase units, as shown in Fig. 1 and 2, function as torque converters only. The stator of a two-phase, single-stage torque converter may free-wheel in one direction, Fig. 3, functionally changing from a converter to a coupling. A unit having four or more functional elements, as shown in Fig. 4, is known as a polyphase torque converter.

Each design of converter has unique torque-capacity characteristics. These characteristics are determined by the shape of the actual fluid circuit, the placement of the working members within the circuit, and the number, shape, area, and angle of the blades in each of the working members.

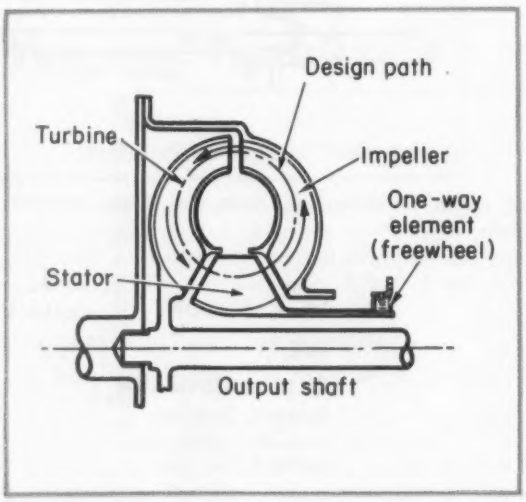

Fig. 3—Two-phase, single-stage torque converter.

The two-phase, rotating-housing, single-stage torque converter, Fig. 3, can be compared directly to a fluid coupling during operation in the coupling phase. Fig. 5 shows a characteristic torque-capacity curve for an actual unit suitable for matching with the example engine discussed in the first article of this series.

Under no-load conditions, the fluid heads are in balance and there is no flow from impeller to turbine, just as in the case of the fluid coupling. Hence, no torque is being transmitted. But, a slight torque is required to overcome turbine bearing, stator freewheel, and windage drag. This no-load condition is represented by point *A* in Fig. 5 and efficiency is zero at this point.

At stall, the converter will absorb 445 lb-ft torque at 1700 rpm input speed, point *C*, Fig. 5. At 1800 rpm, the torque absorbed would be 499 lb-ft, which is in excess of the engine capacity of 292 lb-ft torque. Therefore, the engine speed will be reduced until a balance is reached, just as with the fluid coupling. However, the slope of the converter torque-demand curve, or primary-torque curve, is not as great as that of the coupling. Thus, the engine speed will be reduced to 1400 rpm only. The torque balance occurs at approximately 322 lb-ft.

The match point of the hypothetical example engine is represented by point *B*, Fig. 5. The full net torque of 292 lb-ft is absorbed at the 1800 rpm engine (input) speed. Fig. 5 shows the primary torque required at 1700 rpm. The engine torque corrected to 1700 rpm based on the capacity-speed relationship is

$$292 \left(\frac{1700}{1800} \right)^2 = 260 \text{ lb-ft}$$

The corresponding speed ratio is 0.89, and the efficiency is 86 per cent.

To permit a direct comparison of the fluid coupling and the converter-coupling, the characteristics of both are shown in Fig. 6.

The converter is matched in the coupling range at 0.89 speed ratio and 86 per cent efficiency, while the fluid coupling is matched at 0.96 speed ratio and 96 per cent efficiency. Both units perform as fluid couplings under this condition, but the true fluid coupling appears to be more efficient.

However, at 0.89 speed ratio, or the match point of the converter, the true fluid coupling absorbs 575 lb-ft torque at 1700 rpm input. This load reduces the engine speed to 1500 rpm. The resulting lower power input to the true coupling, less the slip, provides approximately 80 hp to the load. The converter delivers about 86 hp under comparable conditions.

Alternatively, the less severe torque demand of the converter permits the engine to maintain higher input speed as the load increases. This feature, combined with the reaction-torque characteristic, provides for greater power delivery to the load over the major portion of the speed range of the tur-

bine. Thus, the converter permits the use of fewer ratios in those applications requiring a multispeed transmission and reduces gear shifting by the operator.

Primary torque characteristic curves depend upon converter design. Although the difference in characteristics may not be as extreme as shown in Fig. 6, in general, the engine or prime mover speed is approximately proportional to the inverse of the primary torque.

The converter phase and the coupling phase of a two-phase converter-coupling do not have equal horsepower or torque capacity at a given input speed.

If a larger two-phase converter is selected to locate the match point in the coupling range, the slope of the torque-demand curve indicates that excessive reduction of engine speed will result. Hence, the converter would be too large for the engine. Conversely, a smaller unit, which would provide a match point higher on the curve, would permit nearly constant engine or input speed. This match would make good use of the converter phase, but not of the coupling phase. In practice, the location of the match point is determined by the desired operating characteristics of the machine.

Location of the match point is controlled by three variables: 1. Input speed. 2. Capacity or size of the converter. 3. Blade configuration within the converter circuit.

For example, in Fig. 5, a variable-speed engine governor could be provided to permit higher engine speed during the coupling phase. Greater utilization of the coupling phase would result without reduction of performance in the converter phase. Or with a fixed-governed engine speed, a two-speed gearbox on the converter input could provide the performance desired in the machine.

Capacity Ratings

Systems for rating torque converters differ among the various manufacturers. The method employed in this article is a sample rating method and is used simply for illustrative purposes. However, the basic characteristics and application principles apply to all types and makes of converters.

As previously explained, torque capacity varies as the square of the input speed, and horsepower capacity varies as the cube of the input speed.[1] Both torque and horsepower capacity vary as the fifth power of the impeller diameter.

Nomenclature

D = Diameter constant
P_1 = Converter input power, hp
P_2 = Converter output power, hp
M_s = Specific torque, lb-ft
N_1 = Converter input speed, rpm
N_2 = Converter output speed, rpm
T_1 = Converter input torque, lb-ft
T_2 = Converter output torque, lb-ft
T_n = Nominal primary torque (torque absorbed by impeller when output torque equals input torque, at 1700 rpm input speed) lb-ft

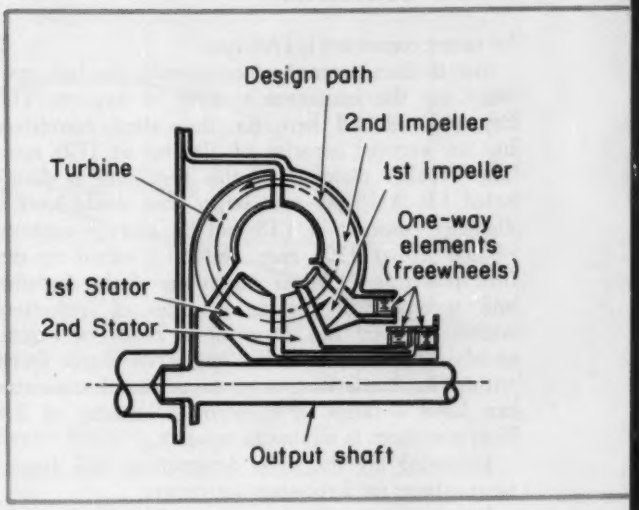

Fig. 4—Polyphase, single-stage torque converter.

A review of the horsepower and speed ratings of the many industrial engines presently available indicates the size of the problem that would arise if a converter with suitable characteristics were furnished for each of these engines. Such ideally matched units could be obtained if cost were no object. However, since cost must be considered, designs are based upon key circuit diameters. Then, minor variations can be made to obtain a range of sizes. Identical tooling and interchangeable components are used whenever possible. These facts lead to the method of rating converters for capacity.

Series Number: Torque converter capacity is determined by two variables—size and speed. Since a converter of one size can be operated at different speeds, an arbitrary reference speed must be established. The reference speed used in this article

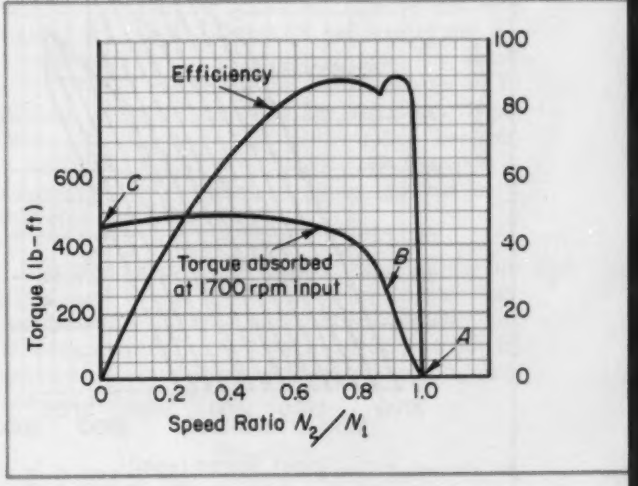

Fig. 5—Torque absorption and efficiency as a function of speed ratio of a two-phase torque converter.

for rating converters is 1700 rpm.

Size is then determined to provide the best coverage for the maximum number of engines. The first size selected here for three-stage converters has an average capacity of 100 hp at 1700 rpm. The impeller diameter of this base unit is designated 1.0. A 15 per cent larger unit would have a diameter constant of 1.15 and an average capacity of 200 hp at 1700 rpm, since 1.5 raised to the fifth power is 2. Minor variations of the impeller and turbine will provide a series of converters within a given size to cover a range of engine speeds and horsepower. For any given engine speed within its limitations, a given series of converter can have a range of horsepower capacity of 2:1 from maximum to minimum capacity.

Following are the series designations and diameter constants for three-stage converters:

Diameter Constant	Series Number
1.0	10,000
1.15	11,500
1.38	13,800
1.6	16,000

As used in this discussion, series numbers of single-stage converters equal the outside diameter of the circuit torus (to the nearest inch) times 100.

Capacity variations within a given size or series can be obtained by varying the number of impeller blades, increasing or decreasing the impeller blade angle, or by increasing or decreasing the outside diameter of the impeller blades. The capacity range can be extended further by changing the number, angle, or (in the three-stage converter only) the length or angle of the last stage of the turbine blades.

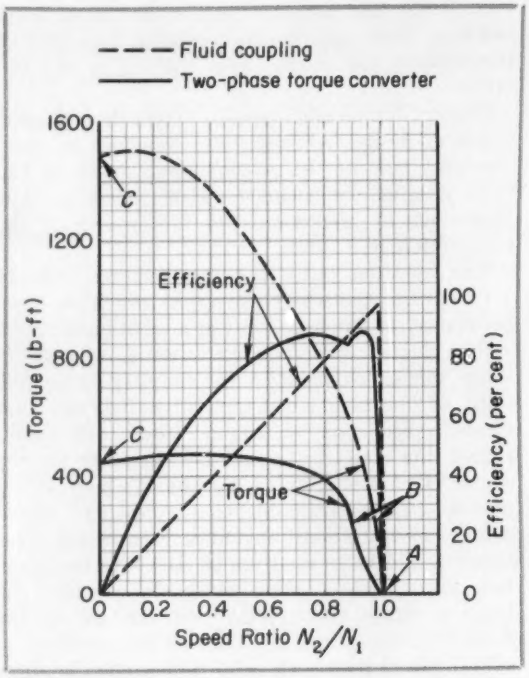

Fig. 6—Comparison of torque absorption and efficiency of a fluid coupling and a two-phase torque converter.

Fig. 7 shows typical horsepower-capacity charts for particular three-stage and single-stage converters. Such charts are usually available for any con-

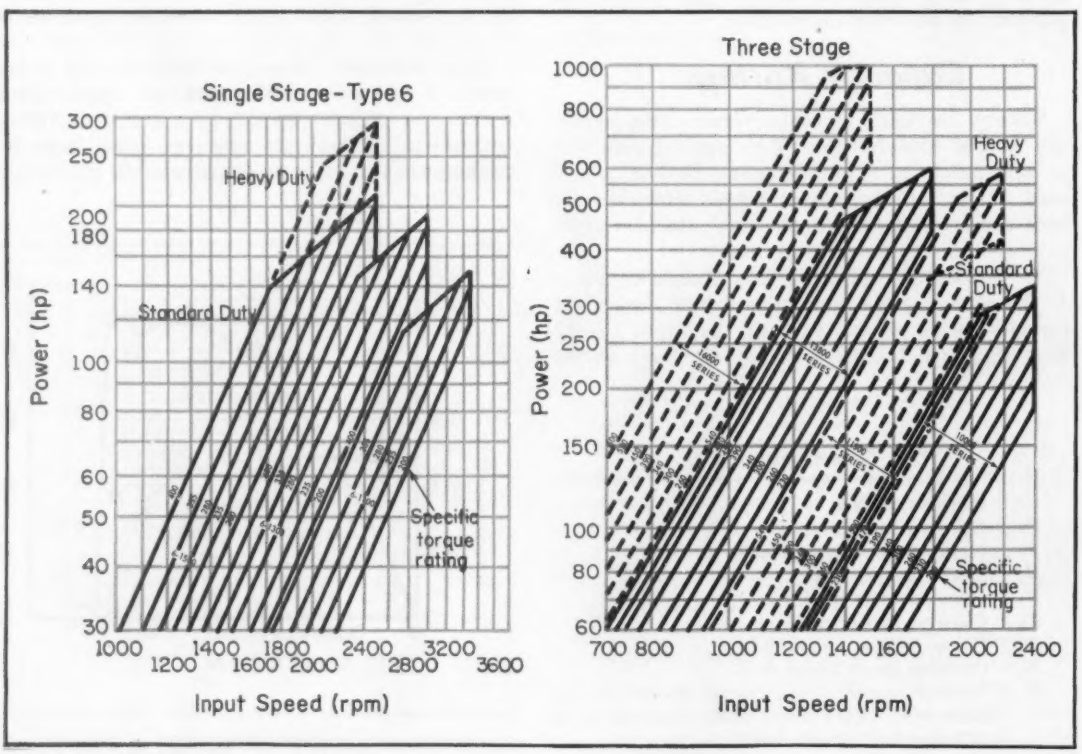

Fig. 7—Sample chart of horsepower capacity.

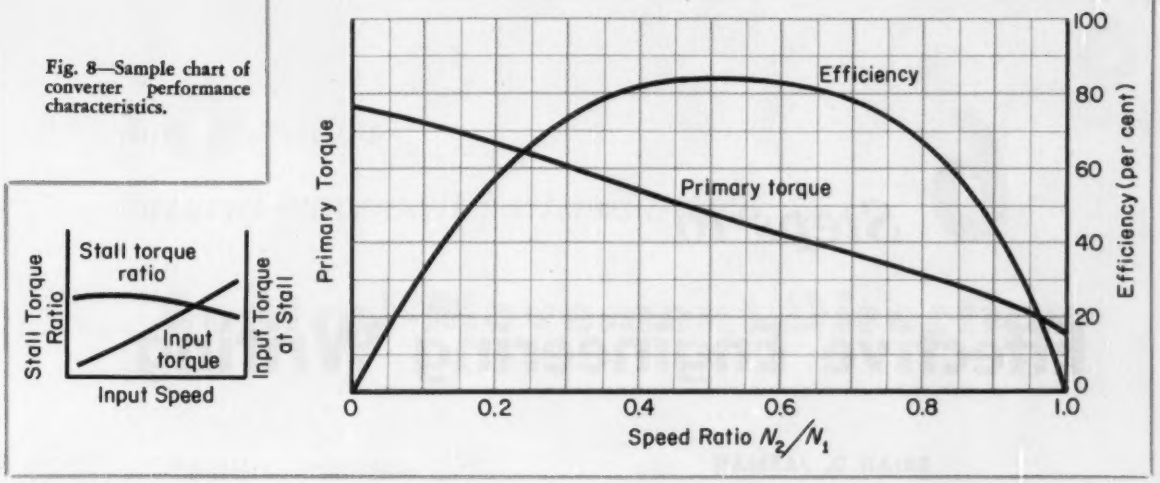

Fig. 8—Sample chart of converter performance characteristics.

verter series in standard-sheet form, and are used only to check the series and approximate M_s rating. Final M_s rating selection should be checked in detail, as explained in the following discussion.

Specific Torque Rating: For a given engine, a converter is usually selected which will absorb maximum net engine horsepower when the converter is operating somewhere between peak efficiency and the point of 1:1 torque ratio. The high speed point of 75 per cent efficiency may be used as the upper limit, if this point is to the right of the 1:1 torque ratio point. To distinguish one capacity from another within a series, the torque absorbed at 1:1 torque ratio at 1700 rpm input is defined as specific torque, or the M_s rating:

$$M_s = T_n \left(\frac{1}{D} \right)^5$$

where D is the diameter constant of the converter. For example, D for the 11,500 series would be 1.15.

In the single-stage converters, the nominal 15-in. diameter or 1500 series converter is the reference size. The proper constant, D, must be used to determine the M_s rating of a given capacity converter. The single-stage series designation divided by 100 gives only the nominal diameter, and this value should not be used as the exact diameter.

Performance Curves

To predict the expected performance of a converter selected for a particular application, the operating characteristics of the converter must be evaluated. These characteristic data can usually be obtained for any converter. Fig. 8 is an example of the type information available. The curves shown are samples only, and are not intended to represent the performance of any specific converter.

Primary torque is the torque which the impeller of a torque converter can absorb at a given speed ratio with the impeller turning at a constant reference speed.

Speed ratio is the ratio of output speed to input speed.

Converter efficiency is the output work divided by input work and can be determined by

$$\text{Efficiency} = \frac{P_2}{P_1}(100) = \frac{T_2 N_2}{T_1 N_1}(100)$$

Stall torque ratio is the torque ratio when the output shaft is stalled. It varies with input speed and is therefore plotted on the small chart at the lower lefthand corner of the primary curve sheet. Torque ratio at any other point on the primary curve equals the ratio of efficiency to speed ratio. The "square law" does not necessarily apply at stall or at speed ratios below 0.10. Therefore, the input torque which the converter impeller can absorb at stall is also plotted against input speed.

Utility ratio is the higher speed-ratio at which efficiency is 70 per cent divided by the lower speed-ratio at which efficiency is 70 per cent. It denotes a nominal range over which the converter should be able to operate continuously with 30 per cent cooling (ability to dissipate 30 per cent of net engine horsepower) without overheating. For example, in Fig. 8 the speed ratio at the high-speed, 70 per cent point is 0.79 and at the low-speed, 70 per cent point it is 0.28. The utility ratio, therefore, is 0.79/0.28 or 2.86. The utility ratio is useful in determining the number of ratios required in a following transmission.

The next article in this series will detail the application of torque converters to prime movers. Succeeding articles will discuss engine-converter performances curves; extreme speed ratios; direct-drive, split-torque, and retarding arrangements; cooling systems; and limiting devices.

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6 *Steps to*

Effective Engineering Writing

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Firestone Engineering Laboratory
Firestone Tire & Rubber Co.
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EFFECTIVE transmission of ideas or information is the primary purpose of engineering writing. Many engineers believe that a flowery, heavy-worded style is the mark of the engineering intellect. In reality, this approach only confuses the reader and dilutes the effectiveness of the information.

Engineering writing is as important a tool as the slide rule. Here are six suggestions for improving the effectiveness of engineering writing.

1 Stop Using Dead Words: Words that carry no weight and have no bearing on the subject matter detract from the vital words which express the intended thought. In the following example, dead words are italicized. They can be removed without affecting the meaning of the sentence.

It is of course possible that input accelerations might be less than anticipated, and *it would then appear entirely likely that* simply locking the system in its neutral position will prevent interference.

2 Get Rid of Repeater Words: Individual words or expressions are wasted when they repeat meanings of words already used. In the following example, the italicized words are repeaters because their meaning is part of the preceding word, "interact."

It measures the extent to which the translatory and angular oscillations interact *upon each other.*

3 Use Tight Words Instead of Slack Ones: Tight words make a sentence crisp. Here is an example in which the slack words are italicized and the tight word is in parentheses.

The facts *account for* (explain) the speed with which the projectile travels.

4 Use Lively Words Instead of Dreary Ones: Lively words give a sentence heartbeat, make it pulsate. In the following sentence, the dreary word is italicized and the lively one is in parenthesis.

When the missile is *ejected* (fired) from the launch tube, *its velocity increases* (it gathers speed) as it *moves upward* (climbs).

5 Choose Moving Verbs Instead of Resting Ones: If verbs are buried in noun forms, all action leaves a sentence. Verbs are as vital to a sentence as wheels are to a car—they keep it moving. Here are two examples. In the first sentence, the verbs are "resting" in the italicized noun forms. In the second sentence, the verbs are out of retirement and take an active part.

The *determination* of the *completion* of the *evaluation* that was referred to in our *discussion,* should be our first *accomplishment.*

First we should *determine* when we can *complete evaluating* the prototype that we *discussed.*

6 Do Not Create Puzzle Sentences: Readers dislike solving a complex sentence to obtain information. Here is a puzzle sentence which reflects confused thinking. The rewritten sentences present the information simply and effectively.

To provide radial clearance for obstruction-free assembly of the tube, each suspension unit is provided with a retracting bolt, not shown, which projects through the inner tube such as to allow each unit to be manually retracted as much as four inches within the inner tube.

A retracting bolt in each suspension unit provides radial clearance for obstruction-free assembly of the tubes. The bolt projects through the inner tube, allowing each unit to be retracted manually four inches.

how operators'

natural movement patterns affect

Control-Movement Direction

JOSEPH L. SEMINARA
Human Factors Specialist
Saratoga, Calif.

EQUIPMENT operators are required to rotate, push or pull, or otherwise displace a control from one position to another to effect a control action. The direction of control motion required to achieve the proper equipment response should not be left to chance, but rather, should be based on natural movement habits engrained in the human operator.

When an unnatural control movement is required of the operator, the most common outcome will be the inconvenience of performing a corrective action to overcome a false start. The problem of false starts assumes importance when time is critical or when the operator is functioning under unnatural circumstances.

In the interest of standardization and conformance to the natural abilities of the operator, certain rules are followed for actuation of controls. Examples are shown in Fig. 1 through 9. Correct direction of control motion depends on such considerations as plane of control movement, position of operator, and relationship of controls to associated visual displays.

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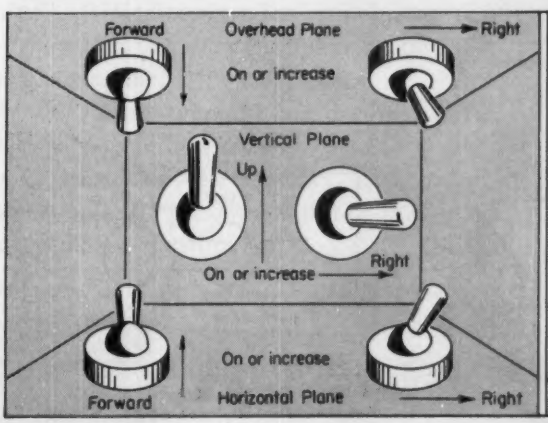

Fig. 1—Toggle or lever.

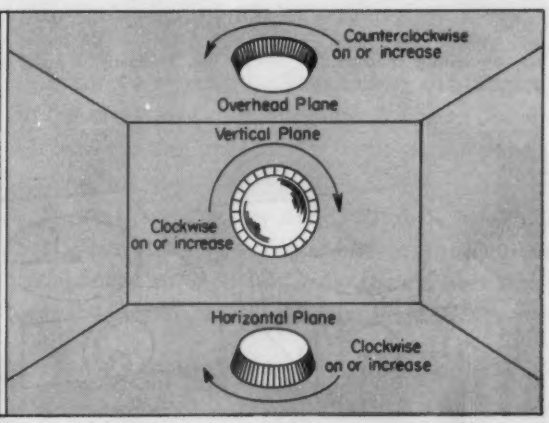

Fig. 2—Knob, handwheel, or crank.

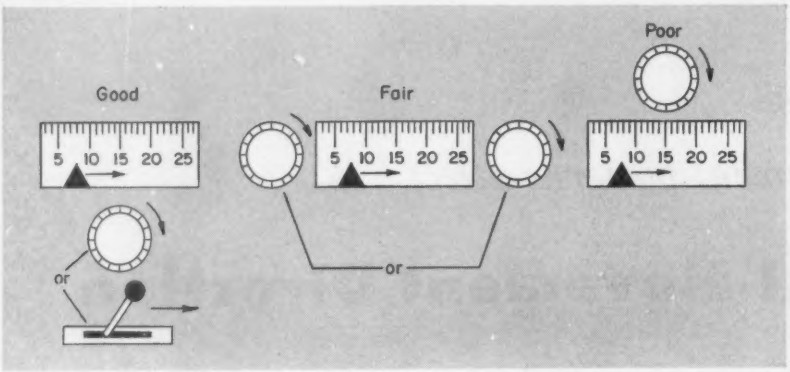

Fig. 3—Setting linear scales, horizontal.

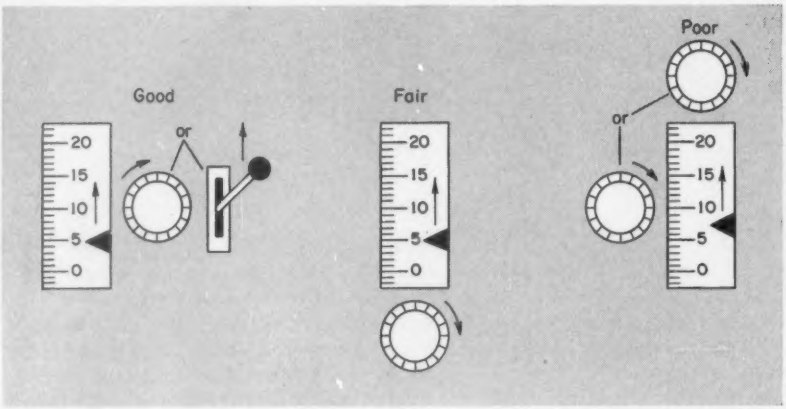

Fig. 4—Setting linear scales, vertical.

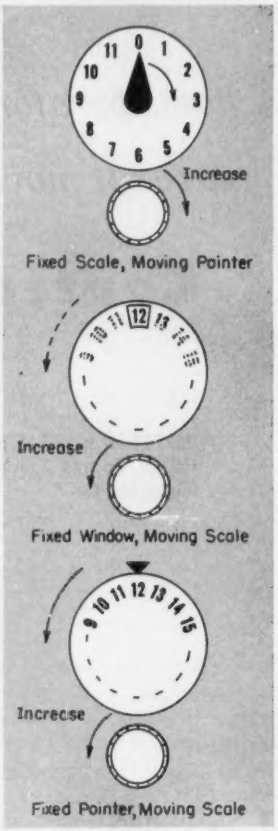

Fig. 5—Setting scale values.

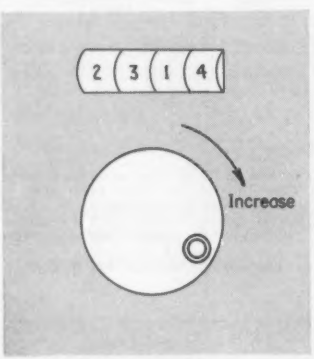

Fig. 6—Setting counters.

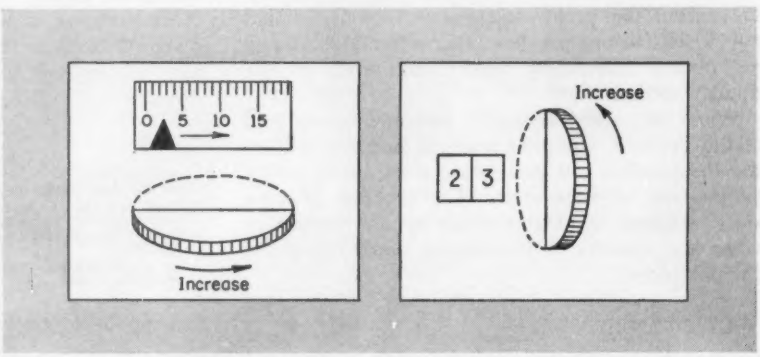

Fig. 7—Partly recessed controls.

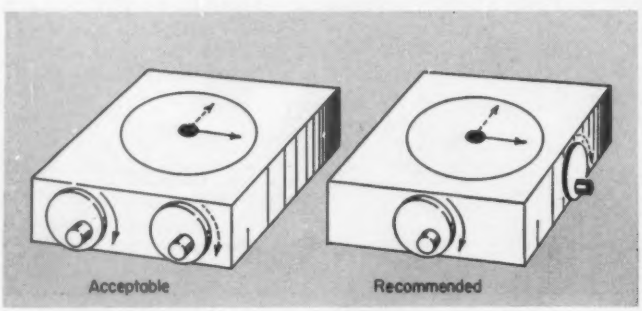

Fig. 8—Two-handed rotary control motions.

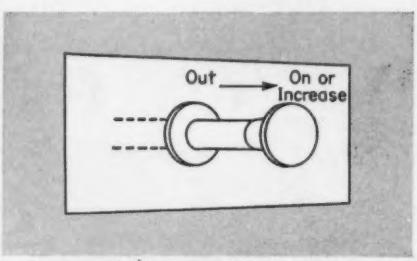

Fig. 9—Push-pull throttle-type controls. For visual determination of control position, the unexposed shaft in the *Off* position is colored yellow.

Experience—*the added alloy in* **Allegheny Stainless**

form
Stainless steels can be bent, drawn, and roll-formed by all the standard techniques known in the metalworking industry. In these operations, stainless requires somewhat greater power and harder tools than it takes to work softer materials. But this characteristic stems directly from stainless steel's superior ability to withstand bending and denting in service.
This attractive stainless cocktail set was produced by flow-turning—one of the newer metalworking techniques that have been developed to offer new answers to many design problems. With these improved fabricating techniques, components that formerly called for two or more materials can often be made better or more economically from one solid material that fills all the requirements of design. The techniques of spinning and abrasive wheel polishing offer special design possibilities, as exemplified by the spun dish on page 7. For further information on the degree of forming possible with a specific type of stainless, contact your nearest A-L office.
Stainless Cocktail Set
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Sample pages from A-L's new free booklet on design

"Design and Allegheny Stainless" is illustrated page after page with hand-picked examples of good design in the gleaming metal.

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The examples are presented with text in terms of Function, Shape, Texture and Color. They cover many fields from automotive parts to holloware for the home . . . to open new horizons for the designer.

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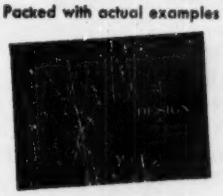

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954

Characteristics of . . .

Structural Adhesives

A. FARLEY THOMSON and ALBERT F. MARTIN
Research and Development
Adhesives, Coatings, and Sealers Div.
Minnesota Mining & Manufacturing Co.
St. Paul, Minnesota

THE ability to carry very heavy loads is a primary characteristic of structural adhesives and serves, also, as a basis for their name. Chemical welding is another suitable term since most structural adhesives are thermoset, chemically-cured materials prior to being exposed to physical stress. Mainly, this article is concerned with two of the more prominent polymer classes: Epoxy systems and nitrile-phenolic combinations.

Nature of Structural Adhesives: These compounded polymers are structural materials themselves. Investigation of free films provides an understanding of their mechanical behavior. Unsupported films have been tested in tension at −67, 80, 180, and 300 F. Results exhibit nearly a straight line relationship in the elastic portion of the stress-strain curve. Beyond this portion, the adhesives exhibit plastic behavior which still has useful load-bearing capabilities. Modulus of elasticity vs. temperature is shown in Fig. 1. Note that decrease of modulus with increasing temperature is nearly the same for the three adhesives. Ultimate tensile strengths in Fig. 2 show a decay of strength with temperature.

Performance of Bonded Structures: Remarks which follow pertain to standard aircraft aluminum (2024 T3 clad) and standard ASTM test

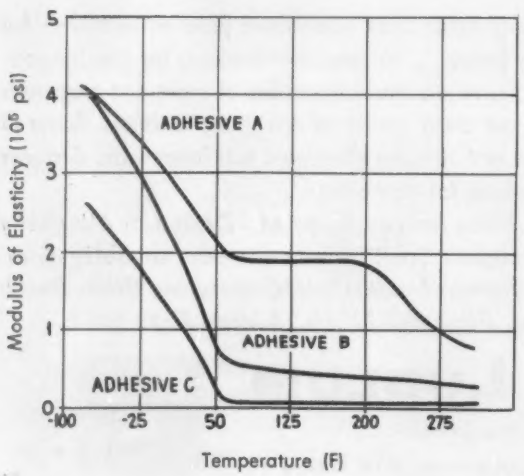

Fig. 1—Variation of modulus of elasticity with temperature for three common structural adhesives.

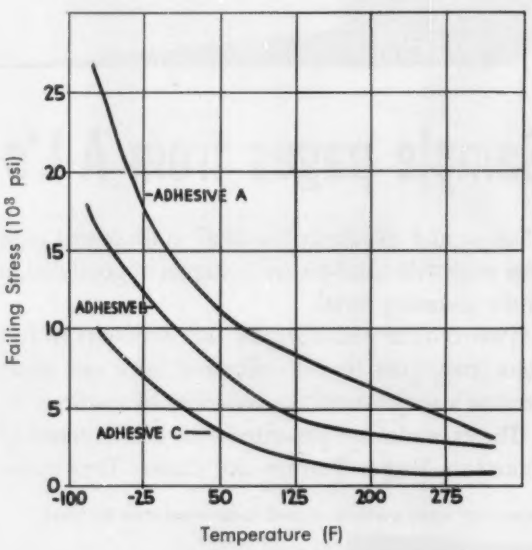

Fig. 2—Variation of ultimate tensile stress with temperature for three common structural adhesives.

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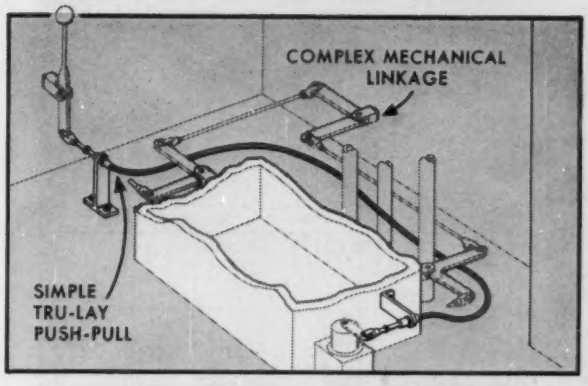


Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

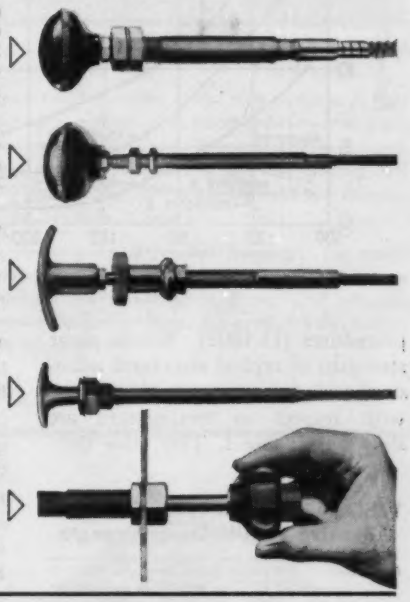
Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.



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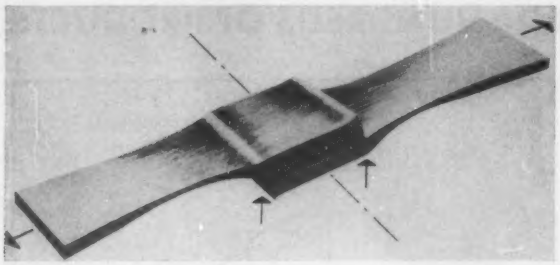
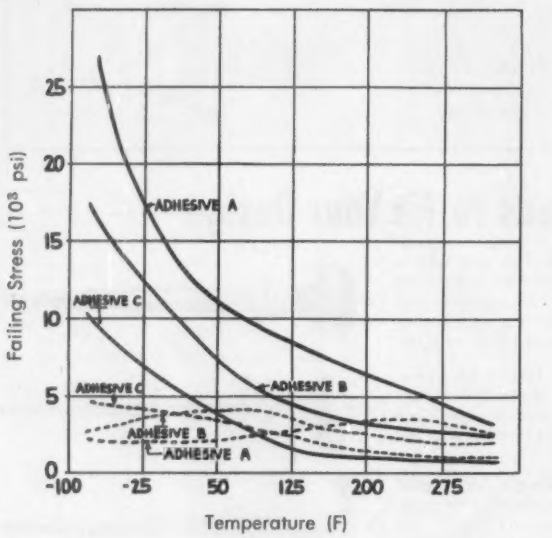


Fig. 3—Distortion of lap joint under tension. Vertical arrows indicate locations of maximum stress in the adhesive.



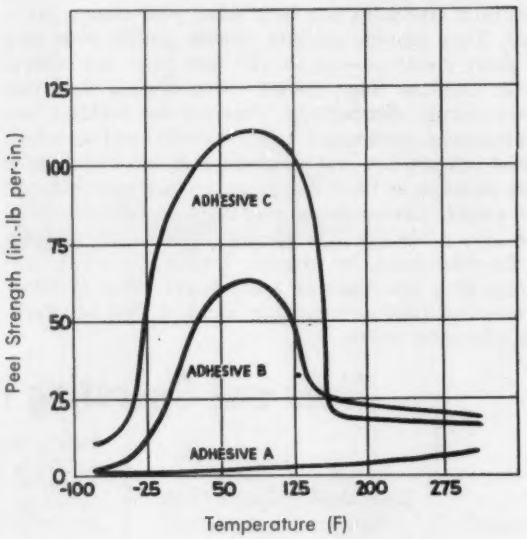


Fig. 5—Variation of peel strength with temperature.

Fig. 4—Relationship of ultimate tensile stress to overlap shear stress for three common structural adhesives. Solid curves indicate ultimate tensile stress. Dotted curves indicate tensile shear strength of the aluminum bond.

procedures (D 1002). Tensile shear strengths of typical structural adhesive bonds (aluminum to aluminum) with respect to temperature are shown in Table 1. This table indicates a high level of strength over a wide temperature range. It is also evident that each adhesive has a distinctive ultimate-stress temperature characteristic.

Table 1—Effect of Temperature on Adhesive Tensile-Shear Strength

Adhesive	Tensile-Shear Strength (psi)			
	−67 F	75 F	180 F	300 F
A	2450	2620	2900	3060
B	3000	3400	2730	2100
C	4100	3050	2130	1010

Properties of adhesives are illustrated by a simple lap joint in which shear forces are not in line initially, Fig. 3. Under moderate load, distortion of the joint occurs because the bond area will not pivot normal to the load. The type of metal to be bonded influences this tendency to distort.

The bending moment which occurs in the tensile-shear test and the resulting peel stresses on the adhesive accounts for the distinctive shear temperature characteristics. In a test at a given temperature, using the same aluminum adherends, a rigid adhesive which is less capable of relaxing these concentrated peel stresses fails at about 2000 psi. Adhesives which are able to relax stresses fail in the 3000 and higher psi range. As temperature is increased, most compositions are better able to tolerate peel stresses.

Another factor which influences average shear is stress concentration in the adherend adjacent to the overlap area, Fig. 3. This stress concentration or differential strain contributes to the peel stresses in the adhesive at the edge of the lap. A plot of shear data on the previous ultimate tensile-stress plots (Fig. 2) of free films is shown in Fig. 4. This graph shows that the bonded joints fail considerably below the maximum strength of the adhesive film. In all cases the bonds fail through the adhesive film. Adhesive C, which has the lowest tensile strength and also the lowest modulus of elasticity, shows the highest metal-to-metal strength at −67 F. Adhesive A is considerably higher to tensile strength and equal in modulus to B, but both produce about the same results at −67 F. From this evidence, elastomer phenolic types offer the best low-temperature strength.

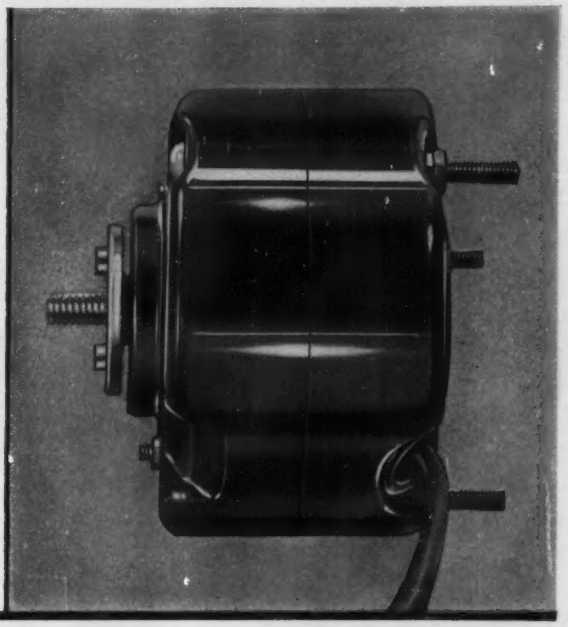
Peel strength is a basic measure of the resistance of an adhesive joint to failure. Fig. 5 shows the change in peel strength with temperature. Peel strength is a function of a stress distribution factor, the cohesive or tensile strength and the modulus of the adhesive.

Another property of structural adhesives is bend strength. This property is determined in a beam-loading test where the overlap assembly is loaded at room temperature at the center of the bond at a rate of 200 lb per min. The typical structural adhesives covered here fail at 130 lb, 190 lb, and 270 lb, respectively.

Structural adhesives are also evaluated for dead-load creep resistance. In the normal structural adhesives, there is essentially no movement at

NEW DUAL-BEARING UNIVERSAL MOTOR

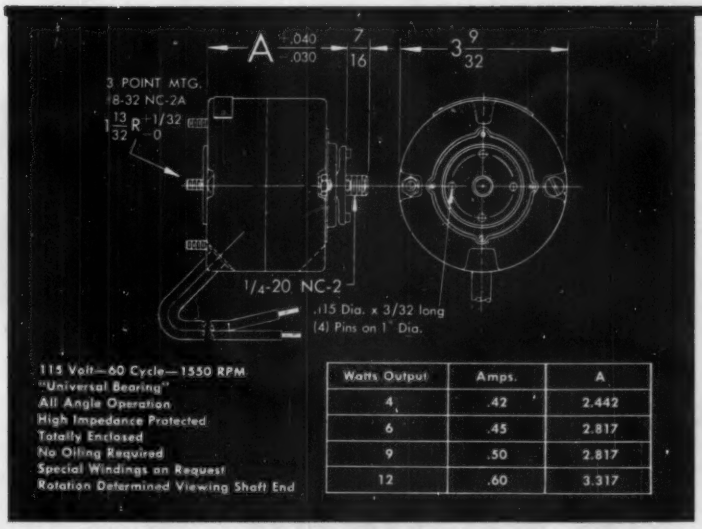
provides dependability and long life in Refrigeration Fan Applications



The Type 118H-3, shaded-pole hubless fan-motor is a rugged, new, precision built motor that has been specially designed to precisely meet the needs of refrigeration manufacturers. The 115 volt-60 cycle-1550 RPM model is totally enclosed and suitable for all angle operation. It conforms to all existing dimensions and has the standard 3-stud mounting and the 4-pin hubless adapter so that it can be installed as original equipment without modification.

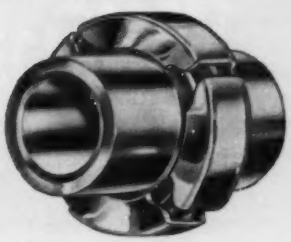
This new Type 118H-3 has two *free-aligning* **Universal Bearings** located at either end of the shaft rather than a conventional single bearing. These bearings are of an advanced design and eliminate fractional HP motor problems due to misalignment. Each has its axis of support at the center, rather than at the end; they are therefore always in balance and adjust themselves to shaft misalignment under any load conditions. This results in longer bearing life and assures a motor that is efficient, sure starting and quieter. These bearings are self-lubricating and each one incorporates an extra large, life-time oil reservoir.

Due to the two *free-aligning* **Universal Bearings**, the newly designed laminations and the improved rotor construction, the Type 118H-3 Universal Motor will provide years of reliable, trouble-free operation. Special windings are available on request; write for complete information.



115 Volt—60 Cycle—1550 RPM
"Universal Bearing"
All Angle Operation
High Impedance Protected
Totally Enclosed
No Oiling Required
Special Windings on Request
Rotation Determined Viewing Shaft End

Watts Output	Amps.	A
4	.42	2.442
6	.45	2.817
9	.50	2.817
12	.60	3.317



New Universal Bearing has support pressure on center of bearing rather than the end to eliminate uneven tension and permit adjustment of axis position to *true* alignment. Neoprene collar around outside surface of bearing accommodates manufacturing tolerances; small metal clips confine collar, allow free sliding movement along bearing support surface.

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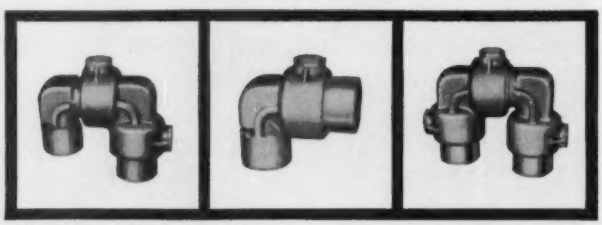
Circle 513 on Page 19

PROBLEM: TORSION FATIGUE ON RUBBER HOSE

SOLUTION: **CHIKSAN SWIVEL JOINTS**

When twisting and kinking on hose lines present a torsion fatigue problem, look to Chiksan for a ready solution. Chiksan Swivel Joints, with free turning 360° rotation allow hose lines to be flexed without the twist caused by fixed position fittings. With Chiksan Swivel Joints hose lines last longer, maintenance and downtime are virtually eliminated.

Call on Chiksan, depend on Chiksan. Over 1000 different types, styles and sizes have been developed for pressures from 28" vacuum to 15,000 psi and temperatures of −70° to +225°F. A nearby representative is ready to analyze your requirements and make specific recommendations. Write today for his name.



Typical Chiksan Swivel Joints

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room temperature. Actual values range from no movement to 0.012 in. Those adhesives, which show no movement at room temperature show a movement of 0.002 in. at 300 F under a load of 800 psi. Those which show a movement of 0.012 in. under 1600 psi at room temperature show the same movement under 800 psi at 180 F and fail under 800 psi at 300 F.

Structural adhesives perform well under vibration. Standard structural adhesives will withstand more than 10-million cycles at room temperature. A 1959 ASTM subcommittee, reviewing fatigue failure experiences in aircraft, found not one instance of an adhesive bond failure due to fatigue. However, there were instances of metal fatigue under the same conditions.

End-Use of Structural Adhesives: The same considerations must be given to the use of adhesives as are now given to welding, brazing, and other conventional methods of joining metals. The joint should be designed to provide the maximum adhesive area to carry all the load possible. The joint should also be designed to place the adhesive under tensile or shear loading as much as possible with the minimum of peeling forces. The surfaces must be clean and the heat energy must be brought to the adhesive in an orderly fashion to effectively complete the chemical reaction.

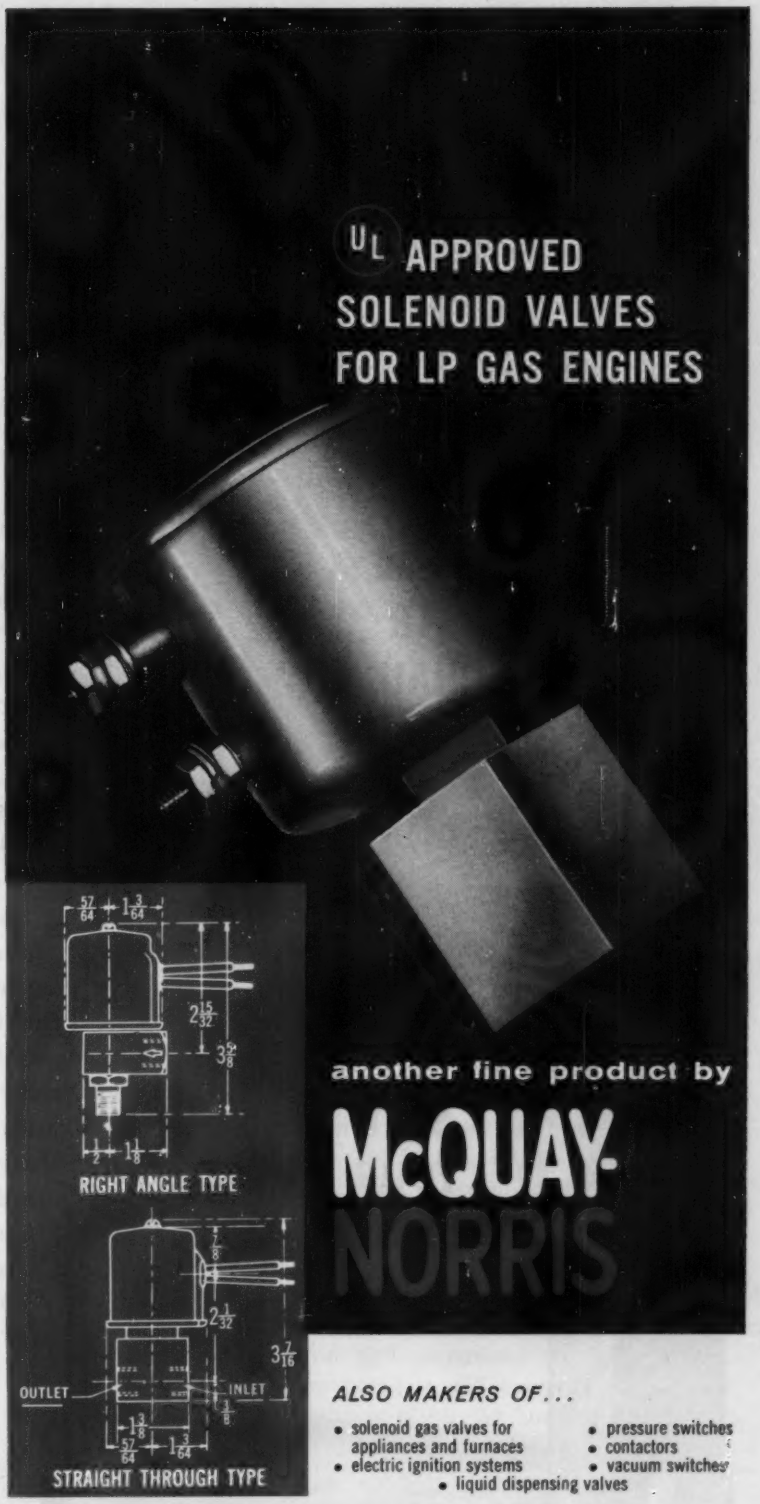
SAE Paper 145A, "Structural Adhesives in Automobiles," *presented at the National Automobile Meeting, Detroit, Mich., March* 1960, 8 *pp.*

lubrication

Lubrication of Antifriction Bearings at High Temperature

A. G. Cattaneo, R. A. Coit, and S. S. Sorem, Shell Development Co.

Protection of antifriction bearings against red rust by oxygen attack, and rapid wear by local seizure (scuffing), at temperatures up to 1100 F. An olefin oxide polymer is a satisfactory reducing agent over the whole temperature range. Conventional extreme pressure additives are effective in preventing scuffing up to about 900 F. Above 900 F,



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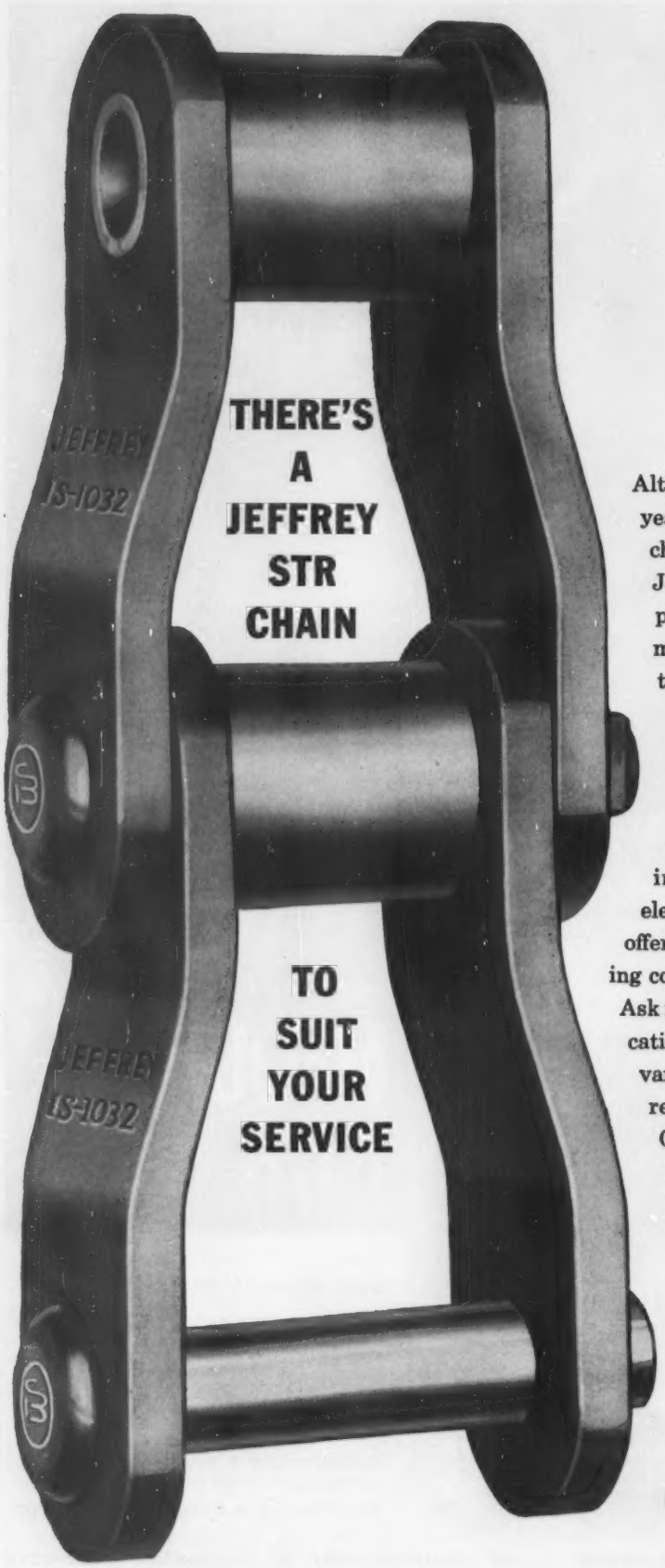

Although Jeffrey patented the principle years ago, STR (Steel Thimble Roller) chain has been constantly improved by Jeffrey to keep pace with industrial progress. Components are designed, materials selected, machined and heat treated to give maximum strength, shock resistance and wearability with minimum weight.

Jeffrey STR chain provides a positive yet flexible means of transmitting power for unit machinery and general industrial drives, and for heavy duty elevating and conveying service. Jeffrey offers four classes to meet various operating conditions.

Ask for engineering assistance on the application of STR chain to suit your needs. The various classes of STR chain are in stock, ready for immediate shipment to you. Chain also can be tailor-made to fit your particular requirements. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

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Circle 516 on Page 19

the polymer forms an organic film which itself gives some protection against scuffing. Satisfactory bearing performance for periods up to 100 hours has been demonstrated at temperatures up to 1000 F, and for 22 hours at 1100 F.

"Operation of Rolling-Element Bearings in a Protective Atmosphere," prepared for The Institution of Mechanical Engineers (Great Britain), 9 pp.

electrical

Acceleration Characteristics of Squirrel-Cage Motors

R. L. Nailen, Motor Engineering Section, Westinghouse Electric Corp.

Starting characteristics to be considered in application of induction motors. Distinctive feature is that the motor develops large starting torque instantly when energized. Inability of the motor to attain full speed as fast as torque is applied causes thermal strain in the motor and mechanical strain on the drive shaft, coupling, and load.

Westinghouse Engineer, *Vol. 20, No. 2, March, 1960, pp. 41 to 43.*

hydraulic

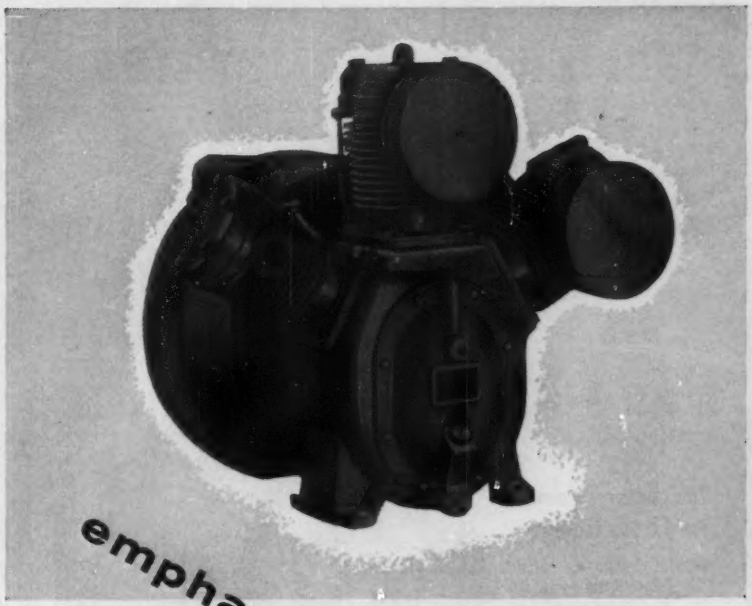
Developments in High-Pressure Hydraulic Equipment

D. E. Turnbull, research engineer, and H. Stephens, information officer, British Hydromechanics Research Association.

Recent advances in the field of high-pressure hydraulics, including work on seals, hydrostatic transmissions, slipper bearings, and other components.

Mechanical or Radial-Face Seals: In the past, no account has been taken of the elastic deformation of the faces which is produced by the pressure of the film. To overcome this effect, grooves may be cut in either or both sides of the ring or rings. Some configurations give much better sealing characteristics at high pressures.

Seals for Reciprocating Shafts: Two main types are the U-seal and the S.E.A.-type seal. Recent results have shown that for U-seals both the slope of the friction versus pres-



Ingersoll-Rand Compressors bring new efficiency to air-operated equipment through modern design and exclusive features. Engineered for trouble-free service and maximum performance, Ingersoll-Rand Air Compressors can be supplied bare, base-plate mounted or receiver mounted.

To assure dependable performance in the equipment you manufacture you'll want to specify an air compressor that's known and recognized as the best. The people you're going to sell *know* that Ingersoll-Rand Air Compressors set the standard for dependable, low-cost operation.

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Other compressors to 6000 horsepower

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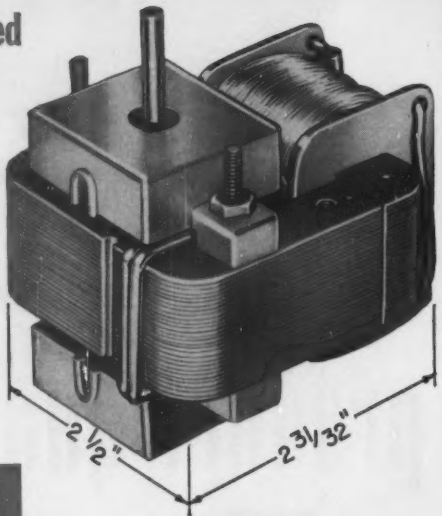
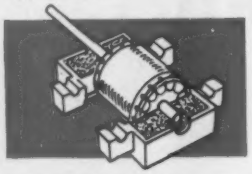
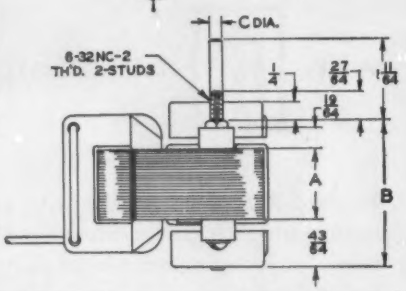
General Industries' Model "H" 2-Pole Shaded-Pole motor is designed and constructed with features that assure thousands of **EXTRA HOURS** of service under the most adverse operating conditions. Rugged, quiet, smooth running. A giant in the small motor field. Available in nine models that cover a wide range of applications.







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Oversized oil bearing reservoirs hold considerably more oil and wicking assuring more efficient lubrication over a much longer period of time.

MODEL	HP 2800 RPM	Locked Torque in./oz.	Max. Torque in./oz.	Free Speed RPM	Amps Free	Watts Free	A	B	C	Wt. Lbs.
H-3-CW H-3-CCW	1/550	0.50	0.75	3300	.150	6.5	3/8"	1 3/4"	.1817"	1.3
H-4-CW H-4-CCW	1/400	0.75	1.00	3350	.200	9.0	1/2"	1 3/4"	.1817"	1.5
H-5-CW H-5-CCW	1/200	1.25	1.80	3350	.250	11.0	5/8"	1 3/4"	.1817"	1.6
H-6-CW H-6-CCW	1/150	1.40	2.20	3375	.270	12.5	3/4"	1 3/4"	.1817"	1.8
H-7-CW H-7-CCW	1/110	1.55	2.50	3400	.290	13.0	7/8"	1 3/4"	.1817"	1.9
H-8-CW H-8-CCW	1/100	1.85	3.00	3400	.300	15.0	1"	2 1/4"	.1817"	2.0
H-9-CW H-9-CCW	1/80	2.00	3.50	3425	.335	17.5	1 1/8"	2 1/4"	.1817"	2.4
H-12-CW H-12-CCW	1/70	2.20	4.35	3450	.390	18.0	1 1/2"	2 3/4"	.1817"	2.8
H-14-CW H-14-CCW	1/55	2.30	4.70	3490	.395	21.0	1 3/4"	2 3/4"	.250"	3.3
H-16-CW H-16-CCW	1/50	3.00	5.00	3490	.400	25.0	2"	3 1/4"	.250"	3.8

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sure characteristic and the frictional force at zero seal pressure can be determined approximately once the radial interference of the seal on the shaft is known. Of special interest is the fact that beyond a pressure of approximately 1000 psi there is no significant increase in the leakage rate. If anything, there is a decrease.

High-Pressure Flexible Hose: Recent tests were made on tolerance to bending. An interesting outcome of this work was that during some static tests it was found that some hoses actually decreased in length when pressurized. This characteristic was found to be related to the angle of the metal reinforcing braid.

"Research and Development of High Pressure Hydraulic Equipment," presented at the Engineering Materials and Design Conference, Earls Court, London, England, February, 1960, 10 *pp.*

Internal-Gear Rotary Pumps For Viscous Liquid Service

S. L. Fry, Pump Sales, L. H. Kessler, Chief Hydraulic Engineer, and S. E. Kotz, Experimental Testing Supervisor, Fairbanks Morse and Co., and R. J. Kinnavy, Chief Rotary Design Engineer, The Deming Co.

How an internal-gear rotary pump is adjusted to deliver a range of heavy liquids efficiently. Stock pumps maintain rated speeds with a selection of rotor diameters for a corresponding range of viscous liquids. Increased rotor clearance decreases the viscous shear encountered and often permits a smaller-powered driver.

ASME Paper No. 60-Hyd-1, *presented at the Gas Turbine Power & Hydraulic Conference, Houston, Tex., March,* 1960, 7 *pp.*

Filtration Characteristics of Felted Structures

Arthur C. Wrotnowski, American Felt Co.

Objectives of this paper are to demonstrate: 1. The advantages of lateral interfacial liquid flow. 2. The advantages inherent in the utilization of fiber diameter for the control of pore size, rather than filter medium density variations. 3. A method of calculation of pore size in felted structures of a given dens-

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to your restricted specifications with

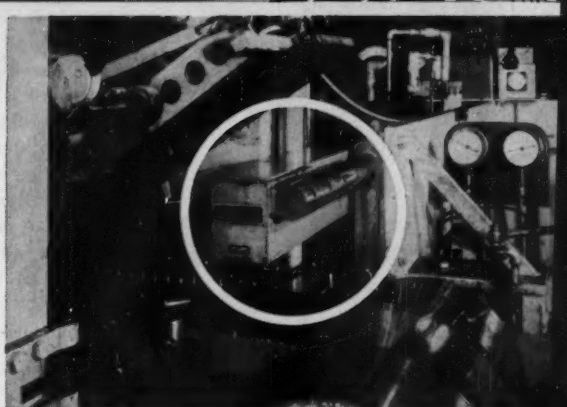
J&L Cold Rolled Strip Steels

In many critical applications, precise gauge control yields worthwhile savings on production costs. Not only does it mean increased tool life but it eliminates grinding for gauge accuracy and reduces quality control costs by minimizing inspection schedules.

At J&L, specially designed cold mills make it possible to exercise precise gauge control — to your specifications. J&L processing techniques include the use of AccuRay gauges to provide exact measurements during rolling. Gauge accuracy is just one of the many restricted specifications which can be met consistently by J&L.

J&L offers you an experienced organization devoted to strip steel processing combined with fully integrated production facilities.

For your convenience, precision strip facilities are available to you in our plants at Youngstown, Indianapolis, Los Angeles and Kenilworth (N. J.)



Typical of J&L precise control is this AccuRay thickness gauge to help assure tolerances on cold rolled strip steels.

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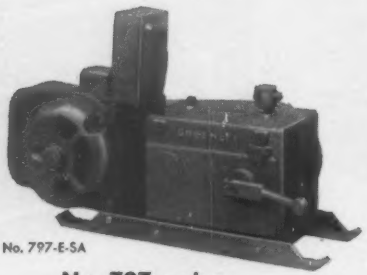
Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

Portable Hydraulic Power Pumps
10,000 psi intermittent
6,000 psi continuous



No. 797-E-SA

No. 797 series
213 cu in. per min. at 10,000 psi

Extra-high-speed drive at high pressure. Applies to a wide range of hydraulic systems. Compact unit . . . pump reservoir, and control valve in one housing. Simply operated, 2-position control handle with advance and return positions. Available with 4-way valve for double-acting rams. Delivers 213 cu in. of oil per min at 10,000 psi with 3 hp a-c motor . . . 106 cu in. with 2 hp motor.

No. 797-G-SA is same pump powered with 4½ hp 4-cycle, air-cooled gasoline engine.

No. 798 series
28 cu in. per min.
. . . at 10,000 psi

Easily carried, high-pressure pump. Has exclusive fast approach . . . high volume, low pressure . . . automatic change-over to low-volume, high-pressure drive. Develops 6,000 psi continuous pressure, 10,000 psi intermittent. Choice of integral 2-way or 4-way valve. Built-in 115 - 230 V ¾ hp a-c motor. Also available with built-in 1.7 hp gasoline engine, universal or low-voltage motor. Write for illustrated data sheets.

ALSO A SELECTION OF HYDRAULIC HAND PUMPS AND VALVES

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GREENLEE

Circle 520 on Page 19

ity. Physical tests indicate that maximum capacity is obtained at slow flow rate (1.0 gpm per cartridge). As a rule of thumb, flow rate of 3.0 gpm can be used to avoid turbulent conditions.

AIChE Preprint 15 presented at the 42nd National Meeting, Atlanta, Ga., February, 1960, 21 pp.

Influence Coefficients for Pressure Vessel Analysis

G. D. Galletly, engineer, Shell Development Co., Emeryville Research Center

A method of obtaining accurate stress distributions quickly without specialized knowledge of shell theory. The method also shows the distribution of bending stresses throughout the shells.

Existing formulas for torispherical and ellipsoidal shells are based on tests of heads of various geometries, include both bending and direct stresses. However, the accuracy of these formulas, outside the ranges of the tests on which they were based, has not been confirmed. Reasons are the complexity of calculations and length of time involved. However, if optimum use of material is desired, plus a realistic knowledge of the elastic stresses in the vessel, bending stresses must be calculated. One method is that of using tables of influence coefficients. By "influence coefficient" is meant the stress or deformation at a point in the shell due to unit values of the edge bending loads or unit values of the pressure. This paper shows how influence coefficients should be used.

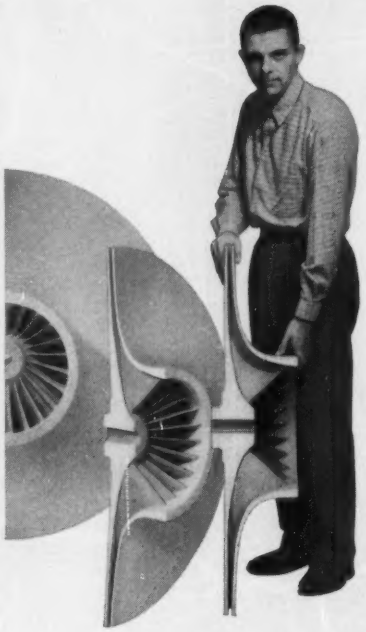
ASME Paper No. 59-A-163, presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 9 pp.

mechanical

Constant Speed Drive Starter Unit

Palmer R. Wood, project engineer, Air Turbine Motors and Drives, Airesearch Mfg. Co.

A multipurpose aircraft engine accessory which efficiently converts adjustable-speed input shaft power into essentially constant-frequency electrical output power during flight. Its functions are: Main engine starting, constant speed drive,



Large aluminum impellers cast smooth and accurate with metallurgical quality for high speed applications are among the specialties of Morris Bean and Company, Yellow Springs 2, Ohio.

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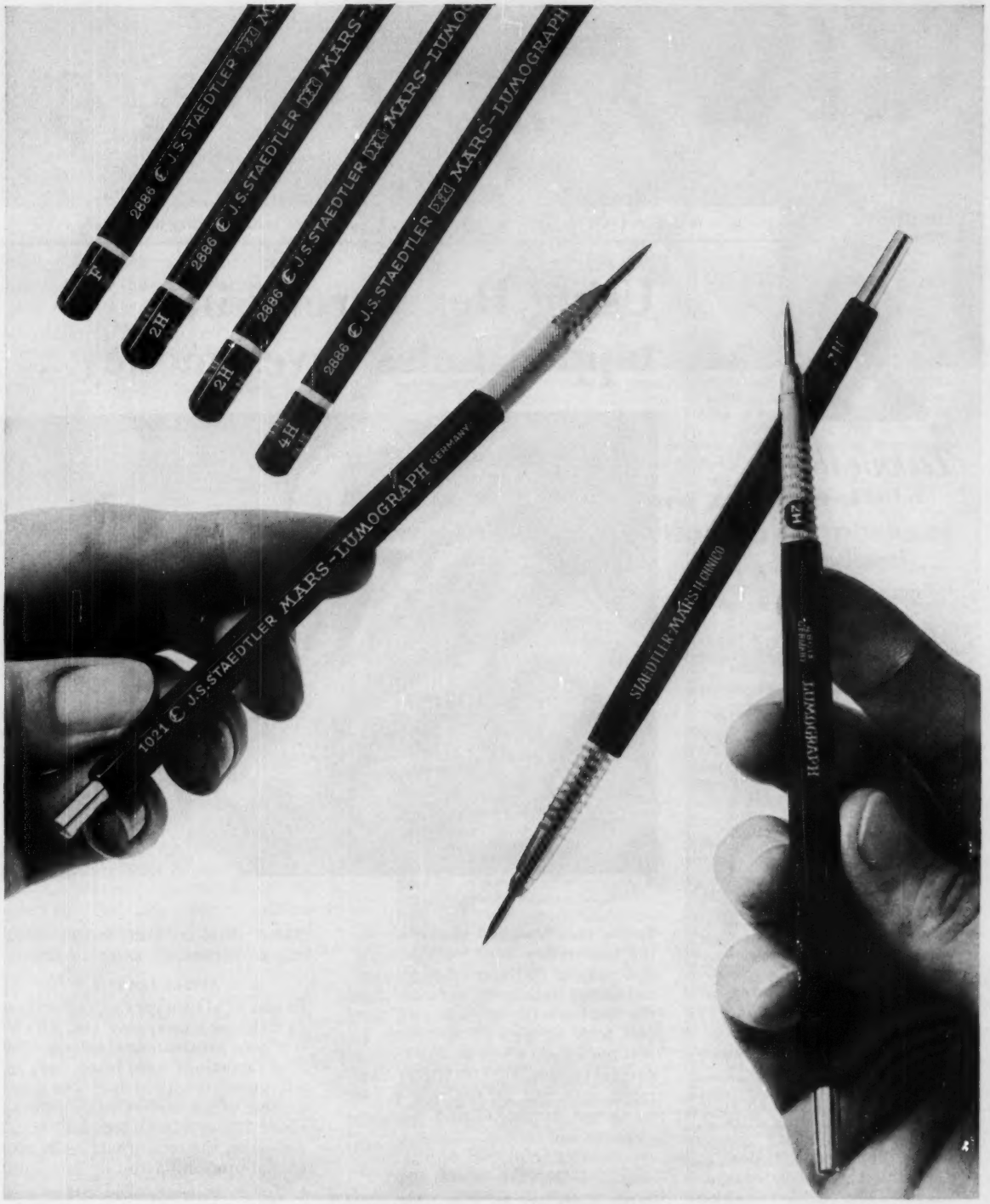

MARS vs MARS— You need neither lawyer nor judge. Let your own preference decide in favor of one MARS over another. For whether you pick one of the wood-cased Lumographs or one of the Technicos you'll be using the very finest.

Among the famous imported Mars drafting products are: the Mars-Technico push-button lead holders (with adjustable degree indicator*, with specific degree imprint*, the economy model*); Mars-Lumograph drawing leads, 18 degrees, EXB to 9H; Mars-Lumograph drawing pencils*, 19 degrees, EXEXB to 9H; Mars-Duralar pencils and leads for drafting on Mylar®-base drafting film —5 special degrees, K1 to K5; Mars-Duralar Technicos with adjustable Duralar degree indicator; Mars-Lumochrom colored drawing pencils, 24 shades. Also: Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads; Mars-Duralar erasers. Mars products are available at better engineering and drafting material suppliers everywhere.

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the pencil that's as good as it looks **MARS**

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HACKENSACK, NEW JERSEY

Circle 522 on Page 19

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of gasketed joints

The right fastener for a "flexible" joint rests on type of gasket material and its compressibility. Total preload on all the fasteners in the connection must be enough only to compress the gasket and provide sufficient additional clamping force to withstand the hydrostatic test pressure. More than this brings on a good chance of leakage, through "bowing" of the clamping plate.

Exaggerated sketch showing how too much torque tends to distort clamping plate and leads to leakage.

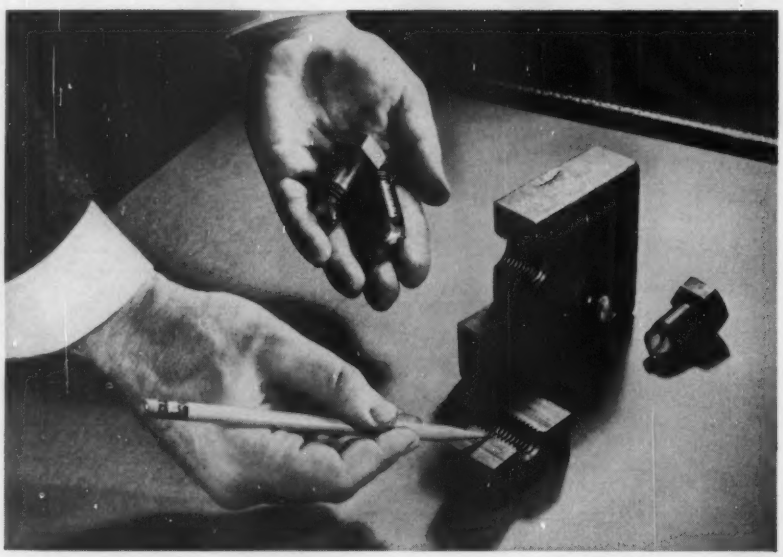
HYPOTHETICAL CASE

Suppose a joint is tightened with Grade 5 Hex Screws to their yield strength, and leakage develops. By going to alloy screws and tightening still further you would still get leakage. But Grade 2 Hex Screws, all torqued evenly, would no doubt solve it.

ACTUAL CASE

The fasteners on one product's flange had to withstand a 4000 pound hydrostatic pressure. But the hard asbestos gasket used took a bolt load of 28,000 pounds for sufficient compression to seal. By substituting a rubber and fibre gasket in this case, bolt load could be reduced. So could bolt size, thereby saving 73% on fasteners.

Using Hex Screws in tapped holes saves money



In the cast "coupon" shown above, the hex screws were torqued tight and removed 50 times—then torqued to failure. Note in the cutaway that the casting's threads are still perfect with no sign of stripping. It was the screws which broke—a clear demonstration that castings fastened with hex screws will suffer no thread damage during repeated disassemblies.

TWOFOLD BENEFIT

When there are no space clearance problems or other special requirements, using studs of 1-inch diameter or smaller often penalizes the user. First, in direct costs, since the more economical hex head screws will do the job to specification. And second, in production costs, since studs require that tapped holes have an *interference* thread fit, which in turn results in slow, "selective" assembly to determine properly mated threads. Hex screws need only a *clearance* fit, assemble faster.

ACTUAL EXAMPLE

In one of his surveys of fastenings used by one company, the RB&W engineer pointed out that over 250 stud fastenings were being used in a large refrigeration unit. The same number of hex screws, costing $8.45, saved $22 over the studs and nuts. Annually, the total would be $7,800 on the production run of this unit.

Not to be overlooked either was the tangible saving on the less critical tapping job required.

RB&W offers its help on your specific fastener problems, or an overall survey of your fastener usage. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 523 on Page 19

ground checkout of complete electrical system, emergency electrical power from engine crossbleed, elimination of separate main engine starter and gear pad, and low heat rejection. Main components are a generator, a gear system, including starting brake, and a starting turbine. The main power input during normal constant speed operation is from the main engine drive pad. Speed control power is supplied by a starter turbine, using compressor bleed or ram air.

SAE Paper No. 128D, presented at the SAE Annual Meeting, Detroit, Mich., January, 1960, 7 pp.

Design Data for Circular Reinforced Plastic Plates

Rolf L. Thorkildsen, mechanical behavior engineer, General Engineering Laboratory, General Electric Co.

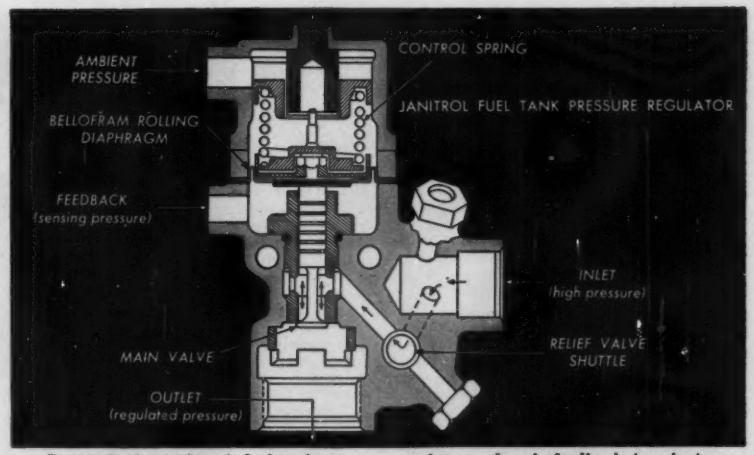
Equations and curves to predict steady-state elastic stresses and deflections in radially and tangentially reinforced circular plates which are loaded symmetrically about the center. These data are required for evaluating short-time behavior, and can be used as an aid in predicting long-time creep characteristics of reinforced plastic structures. A fundamental characteristic of most reinforced plastic materials is elastic aeolotropy; that is, unlike steel, the elastic properties are not constant, but vary depending on direction. For this reason, existing handbook formulas for steel (and other isotropic materials) do not generally apply.

SPI paper 3-C, presented at the 15th Annual Meeting of the Reinforced Plastics Div., Society of the Plastics Industry, Inc., Chicago, February, 1960, 21 pp.

Thermal Instability in High Speed Gearing

W. P. Welch, manager, Gearing Section, and J. F. Boron, design engineer, Gearing Section, Marine Products Engineering Dept., Westinghouse Electric Corp., Philadelphia

A new theory of thermal instability which takes into account the tendency of the thermal effects to be regenerative. This theory provides an adequate and complete explanation for several previously unexplained cases of tooth failure in high-speed high-horsepower reduction gears. Experimental verifica-



In this Janitrol Aircraft fuel-tank pressure regulator, a drop in feedback (sensing) pressure allows combined force of ambient pressure and control spring to increase opening of main flow valve until system is again balanced in terms of ambient pressure. If ambient pressure drops with altitude, causing imbalance due to increased feedback pressure, frictionless Bellofram Rolling Diaphragm responds instantly to close valve. Write for free literature.

Fuel-Tank Pressure Stabilized With Frictionless Rolling Diaphragm

PROBLEM To design a pressure regulator capable of stabilizing fuel-tank pressures in aircraft and missiles despite the following variables: (1) Altitude variations from sea level to 70,000 feet. (2) Compressor bleed air pressures from 12 to 250 psig. (3) Compressor bleed air temperatures from −65°F to +350°F.

SOLUTION Janitrol Aircraft designers concluded that the key to their problem was to find a diaphragm or bellows of compact configuration that would respond instantly to minute variations in pressures. In addition, this device would have to be absolutely leakproof, vibration-proof, immune to aviation fuels and their vapors, and—most important—as friction-free as possible for maximum sensitivity.

The only seal that met *all* these specs was a Bellofram Rolling Diaphragm, which for this application consisted of a high-strength fabric overlay impregnated with a special fluorinated silicone elastomer. In addition to sensitive, trouble-free performance at the prescribed pressures and temperatures, the use of this diaphragm resulted in lower manufacturing cost, for this reason:

Because of the unique *rolling* action of the Bellofram Diaphragm, efficient performance of the regulator does not depend upon close-tolerance machining of the mating piston and cylinder. Hence substantial economies were achieved in the finish, material, and hardness of these heretofore critical parts.

WHAT ARE YOUR SPECS?

If conventional bellows, O-rings, and cup packings do not meet your requirements for use in actuators, pumps, instruments, seals, accumulators, fluid dampers, etc., consider these *additional* advantages of Bellofram Rolling Diaphragms:

They provide frictionless response with positive action in small configurations and can be produced in materials compatible with almost any environmental gas or fluid.

They have no break-out friction or spring gradient effects, and have low hysteresis characteristics. Flex life is often measurable in millions of cycles, and de-icing action is automatic. Over 100 stock sizes are available.

OPERATING LIMITS

Operating Pressures: 1 inch H_2O to +500 psi (up to 1200 psi in some cases).
Operating Temperatures: −85°F. to +550°F. (from −120°F. to +700°F. in some cases).
Cylinder Bore Sizes: .25 to 12 inches.
Effective Pressure Area: .028 to 108 sq. in.
Total Stroke Capabilities: .01 to 12 inches.
Sidewall Thickness: .008 to .035 inches.

nothing rolls like a

Bellofram®

rolling diaphragm

BELLOFRAM CORPORATION, 20 BLANCHARD RD., BURLINGTON, MASS.
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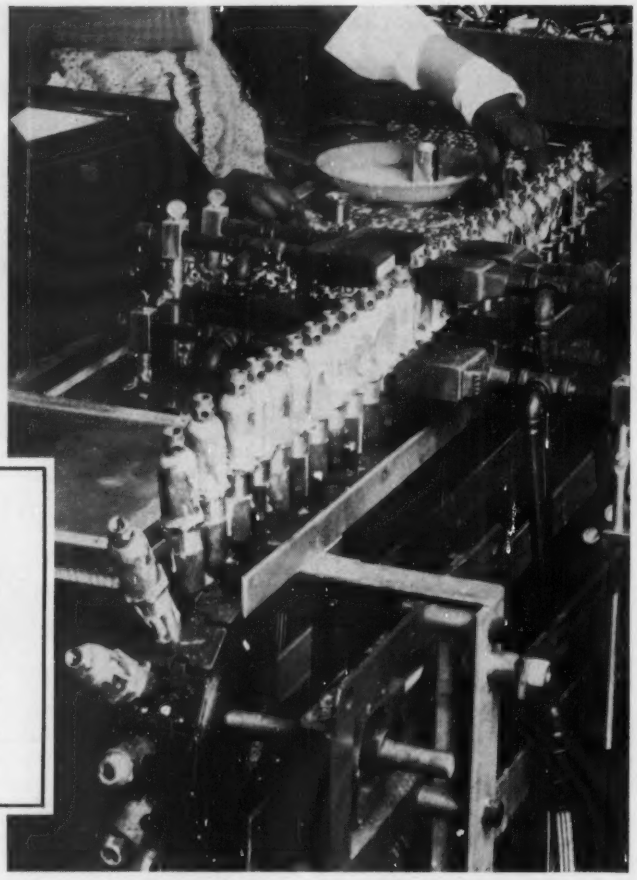

Operator dips parts in HANDY FLUX and assembles them with EASY-FLO 45 rings on a moving rig. Assemblies then pass between banks of gas burners to complete brazing process. Capillary action of EASY-FLO brazing alloy insures thorough penetration—guarantees high strength, leakproof joints.

Flair No. 21 Hot Water Air Vent consists of the basic free-venting air valve, a generous air-collection chamber and a massive hex base. Two preform rings of EASY-FLO 45 are used in the brazing operation. Valve assembly at left was subjected to extreme pressure. Note how body ballooned; joints strong and leaktight.

How Flair Manufacturing Speeds Production, Eliminates Costly Casting With Easy-Flo Brazing

Never a field failure in any joint brazed with EASY-FLO 45 and HANDY FLUX—that's the proud record of Flair Manufacturing Company, Brooklyn, New York, makers of an extensive line of air valves and other specialties for steam and hot-water systems.

Flair finds that brazing with EASY-FLO 45 offers competitive advantages in every aspect of design, production economy and service life. Big savings are made through elimination of costly casting equipment and more productive use of space. Production is smoother, faster. Valves look better, last longer... in tests to 5000 psi, valve bodies burst while brazed joints remain intact. All this for an alloy cost per unit of approximately 2½¢ for two preform rings of EASY-FLO 45.

Speed, strength, economy, low labor costs—advantages *any* manufacturer would be glad to have. And, all achieved through use of Handy & Harman silver alloy brazing. Chances are silver alloy brazing could benefit your product too. If it could, or if you think it *might*, don't hesitate to get in touch with Handy & Harman. We'll help you in every way possible. Why not call us today?

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Circle 524 on Page 19

tion of the theory is presented and some of the conditions for avoiding thermal instability are described.

ASME Paper No. 59-A-118, presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 13 pp.

Construction and Behavior Characteristics of Tires

T. French, Tire Design Div., Dunlop Rubber Co., Fort Dunlop, Birmingham, England.

Recent developments in automobile tires over the past few years have led to certain improved performance characteristics and also to a wider choice of tire behavior patterns. To obtain optimum required performance characteristics for a particular vehicle design, attention must be paid both to individual tire parameters and their interaction with particular features relating to the vehicle.

New materials for making tires and constructional variations in tires have improved performance, including comfort, road adhesion, ease of control, high-speed running, tread-pattern life, noise, and power consumption.

Presented at an Ordinary Meeting of the Automobile Division, The Institution of Mechanical Engineers (Great Britain), February, 1960, 15 pp.

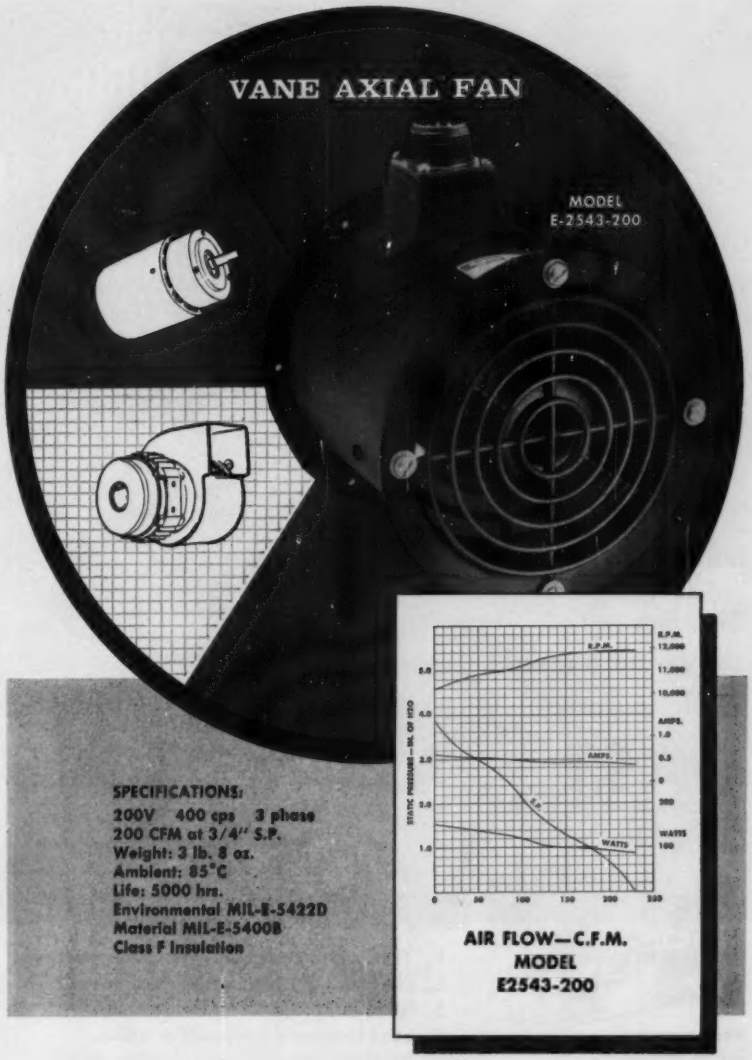
techniques

New Materials For Product Models

Edward Ferrari, manager of the Model Shop, Industrial Design Operation, Housewares Div., General Electric Co.

New materials, mainly plastics, permit the duplication of prototype product models. Duplicates are needed as the functions involved in the evolution of a product increase. Model reproductions are cut into sections to simplify the work of the engineer in making detailed drawings. As prototypes, they serve in testing the engineering design.

Epoxy resins, because of their molecular structure, produce castings at ambient temperatures having good dimensional stability and impact strength. Developments in hardener catalysts and promotors have improved their temperature resistance. The addition of poly-



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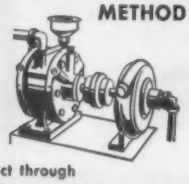
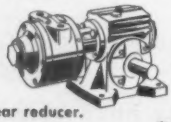
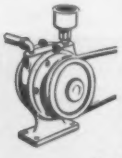


Direct through flexible coupling.



Use gear reducer.

Flange mounted – vertical operation.



Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

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"Air may be your answer!"

sulphides, polyamides and hydroxylphenols imparts controllable flexibility to the epoxy when needed. Recently, "water white" epoxies have been developed for clear castings. Glass can be simulated by allyl polyesters, polyester-methyl methacrylate-styrene monomer copolymers and acrylic syrus. Vinyl parts can be molded with temperature - resistant modified epoxies. Epoxy cavities can be used to electroform metal parts, and cast epoxy parts can be plated to simulate actual metal parts. Eutectic metals and fluxes developed in recent years permit the fabrication of metal models.

"New Materials and Their Influence on the Model Shop," SPEctater, Western New England Section, Society of Plastics Engineers, Vol. 1, No. 7, pp. 142 to 147.

Approximate Synthesis of Spatial Linkages

J. Denavit, and R. S. Hartenberg, Dept. of Mechanical Engineering, Northwestern University.

Synthesis of spatial linkages to generate functions of one variable between nonparallel axes. Three cases are considered in detail:

1. The spherical four-bar linkage.

2. A variation of the four-bar linkage in which two turning pairs are replaced by ball-and-socket joints. This linkage may be designed to generate arbitrary functions with up to seven accuracy points.

3. A second variation of the four-bar linkage where three turning pairs are replaced by cylinder pairs. This linkage can be designed to generate a variable-pitch helical motion with three accuracy points.

ASME Paper No. 59-A-24, presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 6 pp.

Dimensionless Parameters for Helical Compression Springs

R. J. Erisman, chief engineer, Design Analysis, International Harvester Co.

A system of parameters which enables the spring designer to graphically portray the large number of complex variables for a given problem. These variables must be related to the allotted space which the

Circle 526 on Page 19

There's a size and type to handle almost anything that flows

Snap-Tite can provide the right size valved coupling for most any use . . . with quick off-on action wherever coupling or shut-off is required.

"H" series valved couplings for high pressure applications. High resistance to heavy line surge. Sizes from 1/8" through 6". Larger sizes on special order.

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Snap-Tite valved couplings are available with two-way or one-way automatic line shut-off. They are normally furnished in alloy steel. Also available in brass, aluminum, or stainless steel with a variety of finishes.

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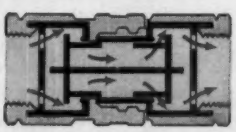

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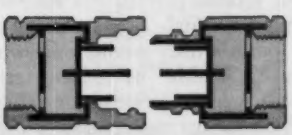

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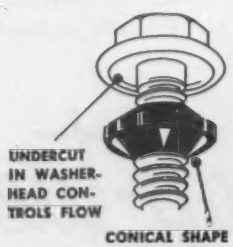
Tuff Tite advantages include ease and economy of installation, surface protection and vibration resistance. Standard items are immediately available from jobbers and warehouses. Tuff Tites are also available in numerous special designs to suit any application need.

If you are joining metal, plastic, porcelain or asbestos, you should know about Townsend Tuff Tites. Ask your Townsend representative, or we will send you complete literature. Townsend Company, Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pa.



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spring will occupy and to the desired load throughout the working range. Derivations are based on the total number of coils as well as the outside diameter. These parameters accurately define the entire space required for the spring. Charts are presented for springs with two dead coils and a torsion modulus of 11,500,000 psi.

ASME Paper No. 59-A-30, presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 4 pp.

processes

High-Temperature Gas Carburizing

Orville E. Cullen, Surface Combustion Div., Midland-Ross Corp.

Notes on the application of high-temperature gas carburizing as a production process. "High-temperature" is considered to be 1800 F and above.

SAE Paper No. 149B, presented at the National Automobile Meeting, Detroit, March, 1960, 6 pp.

Design and Application of Investment Castings

I. L. Gwynn, director, P. I. Castings Ltd.

State-of-the-art summary for the investment method. Modern trends toward the conservation of material and demands for accuracy of dimensions, as well as of form, have given greater prominence to the aims of shaping metal direct from the molten state to a finished product.

In determining the form of a component, the design engineer is frequently frustrated by the inflexibility of the manufacturing processes at his disposal and is, therefore, bound by the practical consideration of how the parts he designs are to be manufactured. The investment-casting process permits the combining into a single casting two or more parts which would otherwise require assembly by other techniques. A broad principle to follow is to avoid sharp corners and sudden changes of section.

Comparative yield of useful metal in the form of finished-machined investment castings is considerably higher than nearly all other manufacturing processes. It follows,

Circle 528 on Page 19

WARNER'S new miniature electric brakes and clutches

give you direct automatic actuation

Take advantage of *direct* automatic actuation for aircraft components, computers, and similar low-torque instrument drives!

Warner's miniature RF-80 electric brakes and SF-80 clutches use simple control circuitry for instant actuation, automatic indexing, smooth inching and jogging, rapid cycling, accurate synchronization, and positive engagement of torque loads up to 1.5 lb-in.

Electromagnetic principle permits stepless torque modulation, automatic operation, and remote actuation from various standard controls. D-c voltage is adjusted easily for cushioned or abrupt couples or stops.

Compact design (approximately 1" dia. x ⅛" length) provides high torque per inch while controlling complex mechanical movements in limited space. Two-piece floating armature avoids complex alignments during assembly.

Operate instantly in any position of rotation . . . no notches, teeth, or lugs to match up. Used for accurate indexing or linear positioning without positive stops.

See the speed, adjustability, and control-*ability* of Warner miniature electric brakes and clutches on your own desk top! Your Warner representative has a plug-in demonstrator that simulates a variety of start, stop, inching, jogging, or torque-adjustment applications. Phone him today, or ask us to arrange an appointment.

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Complete line—from 1.5 lb.-in. to 700 lb.-ft.

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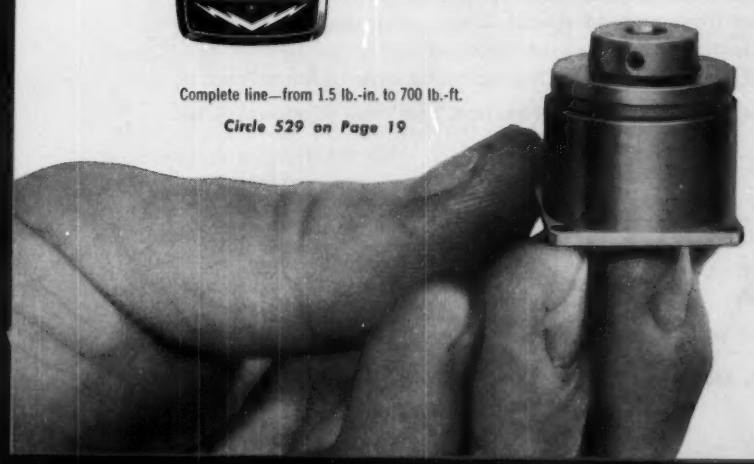
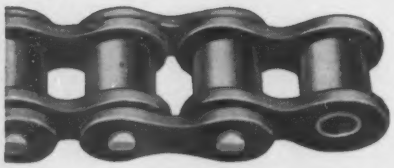
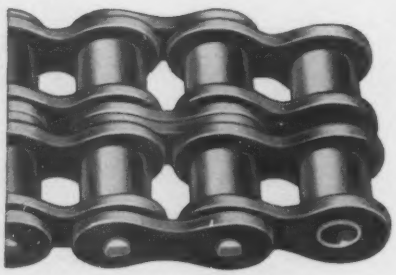
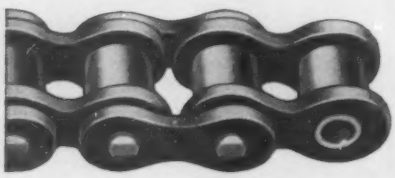




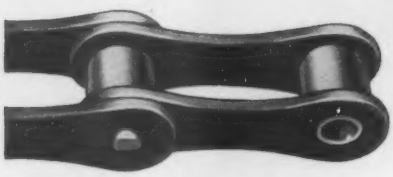
SINGLE STRAND



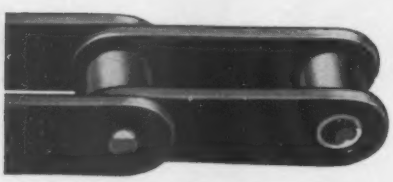
DOUBLE STRAND



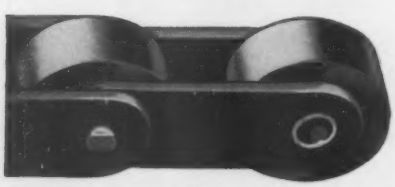
SINGLE STRAND, HEAVY SERIES



DOUBLE PITCH TRANSMISSION

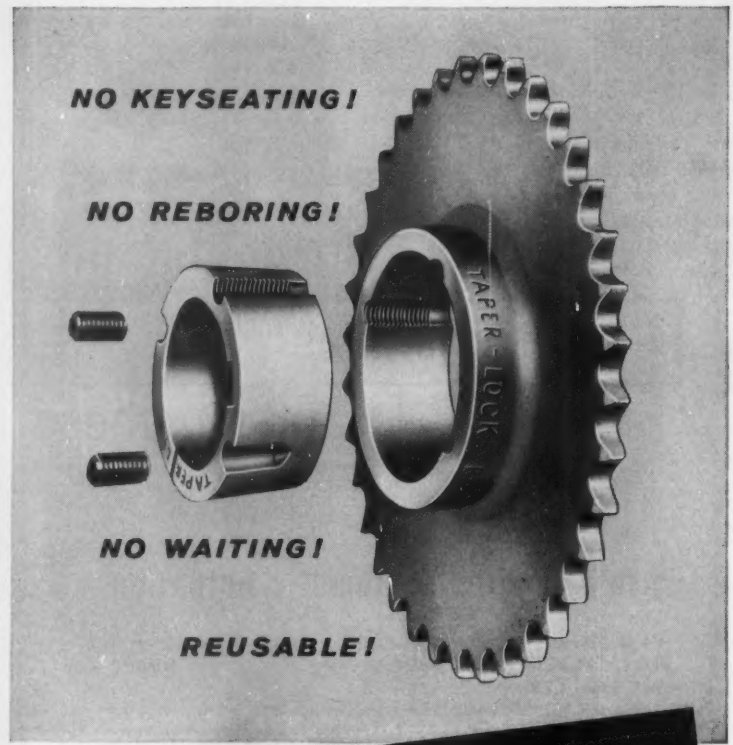


DOUBLE PITCH CONVEYOR



DOUBLE PITCH CONVEYOR, LARGE ROLLERS

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."



TAPER-LOCK SPROCKETS DODGE ROLLER CHAIN

DODGE Quality Roller Chain, teamed with Dodge Taper-Lock Sprockets, results in chain drives and chain conveyors that have the precision, efficiency and stamina necessary for the real economy of *long life*.

Moreover, Taper-Lock's reusable bushing makes a difference in overall cost. The ease of Taper-Lock mounting, the elimination of reboring, keyseating, and wasted time, add to the saving. Precision machining and true articulation lengthen the life of *both* sprocket and chain.

The Dodge line of chain, including standard attachments, is extensive. It meets a high percentage of all chain requirements.

In the Double Pitch series (both Transmission and Conveyor) the sizes which require special spacing for perfect tooth action are offered from stock in special double pitch design — to double the life of the chain and the sprocket!

Ask your local Dodge Distributor. Or write us for bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

DODGE
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therefore, that less consideration has to be given to the cost of the material used.

"Design and Application of Investment Castings Produced by Centrifugal Methods," presented at the Engineering Materials and Design Conference, Earls Court, London, England, February, 1960, 10 pp.

Forgings and Extrusions by High-Energy-Rate Process

F. A. Monahan, manager, Manufacturing Development and Process Specifications, Convair

Development of a compressed-gas actuator that releases high-level energy with precise control of the acceleration-time wave form. This new machine can produce accurately controlled energy up to 450,000 ft lb at velocities up to 2000 ips to do a variety of metal working operations. Complex forgings and extrusions can be produced to very close tolerances, and little or no subsequent machining is required.

ASTME paper "Precision Forgings and Extrusions by the High-Energy-Rate Process," *presented at ASTME West Coast Seminar, Metal Forming, March, 1960, 12 pp.*

management

Simplification of Engineering Paperwork

H. A. Helstrom, Jr., chief administrative engineer, Chance Vought Aircraft, Inc.

Meaning of paperwork simplification, and how to go about it. Case studies include a design-change system.

A questioning attitude is essential: What is done? Why is it done? Where should this be done? When should this be done? Who should do it? How should it be done?

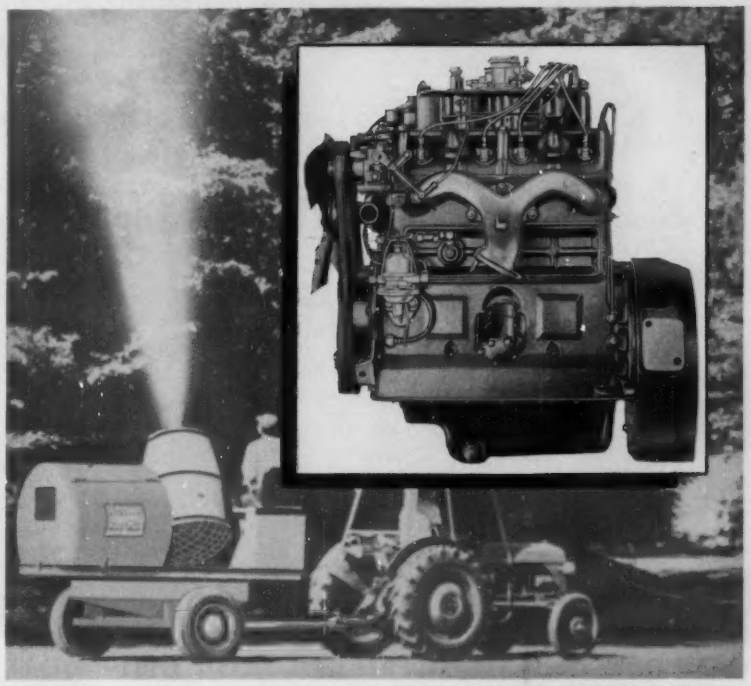
At all levels, individuals should participate by asking themselves: Why do I receive this information? Is it necessary or just convenient? How much does this information cost and is it worth it? Why do I receive this information as often as I do, and what would happen if I didn't receive it at all?

The most unpredictable aspect of simplification is its effect on people. Quoting and paraphrasing Lillian Gilbreth:

MORE SPRAYER MUSCLE

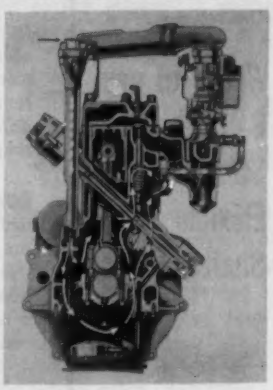
'Jeep'®

INDUSTRIAL ENGINES



For up to 55 continuous duty hp:

The mighty 4-cylinder 'Jeep' Industrial Engines supply power for hard-working JOHN BEAN sprayer units... just one of the many jobs for which these engines supply extra muscle. Where a tough, *proven* performer is needed, 'Jeep' Industrial Engines have what it takes. The 4-cylinder 'Jeep' is available in an L-head design and a unique, "deep-breathing" F-head design.



KEYPOINT ENGINEERING MAKES THE DIFFERENCE.
'Jeep' Engines are fortified to deliver more power, continuously, than any comparable engine of its size and price. The parts that work the hardest are built the strongest! Among keypoint features are hard chrome compression rings, positive valve rotators, and stellite or eatonite valves... at no extra cost.

ANOTHER 'KEYPOINT' FEATURE:
Positive Crankcase Ventilation
The 'Jeep' Engine's ventilating system *automatically regulates* the internal air flow, according to the engine speed. The engine is kept free of dust and dirt, and oil-thinning condensates are quickly removed.

KAISER WILLYS MOTORS

Write for literature and prices
WILLYS MOTORS, INC.
Industrial Engine Dept.
Toledo, Ohio

Manufacturers of 'Jeep' 4 and 6 Cylinder Industrial Engines

Circle 531 on Page 19

S. S. White DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

More Savings with Ready-to-Attach S. S. White Standard Flexible Shafts

NEW, EXTRA-HEAVY-DUTY SHAFT ADDED TO "OFF-THE-SHELF" LINE

Here's a time and money saving idea... the majority of flexible shaft needs can be met with ready-to-attach S. S. White **standard** flexible shafts.

This line has been recently expanded by the addition of the .500" dia. standard shaft to handle extra-heavy loads.

Flexible shafts allow you to simplify design ... position controls and driven parts to best advantage... eliminate expensive gears, universals, rods and costly alignment problems.

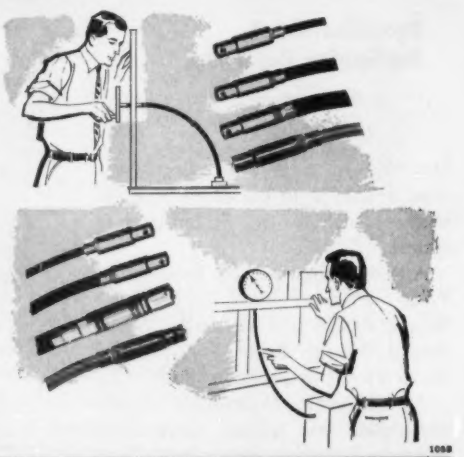
S. S. White **standard** flexible shafts are low in cost and readily available because they are **stock** items. They save you engineering time because the designing has already been done for you by S. S. White, first name in flexible shafts. **They come complete and ready to attach directly to your mating spindle.**

Another plus! Convenient, low-cost, readily available, S. S. White standard flexible shafts are the ideal way to test the advantages of flexible shafts in your products.

Where to use S. S. White Standard Flexible Shafts

REMOTE CONTROL of valves, actuators, switches, indicators and other mechanical or electrical equipment. S. S. White standard remote control flexible shafts come in four different shaft diameters to handle a wide range of requirements.

POWER DRIVE for an endless variety of applications ... portable tools, instrument drives, machine tools, pumps ... anywhere the designer needs to transmit power around obstructions or to movable parts, by means of a single, self-contained, easily applied unit. Four standard sizes.



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S. S. White IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION (Dept. 4)
10 East 40th Street, New York 16, N.Y.

Selection of S. S. White standard flexible shafts: complete description and application data available. Write for bulletin 5801.

WRITE FOR COMPLETE DATA!

Selection of specialized flexible shafts to meet unusual requirements: useful shaft data and also information on how to take advantage of S. S. White engineering services. Write for bulletin 5601.

Circle 532 on Page 19

"1. You have to deal with and through people

"2. People have feelings; emotions

"3. These feeling and emotions are important

"4. And DON'T YOU FORGET IT."

SAE Paper No. 156A, "Reducing the Paper Mill Through Methods and Systems Simplification," presented at the SAE National Meeting, New York, April, 1960, 5 pp.

materials

Chemical and Mechanical Behavior of Cermets

Thomas S. Shevlin, Engineering Experiment Station, Dept. of Ceramic Engineering, Ohio State University.

Chemical character is described by reference to sintering behavior, reactions in strongly reducing environments, and oxidizing reactions in air. Mechanical behavior is described in terms of bond types within the phases of the cermet and the mechanical interaction between the crystals of each phase constituting the cermet.

Metal contents of approximately 40 per cent by volume result in cermets with high impact-energy absorbing ability. Beyond 40 per cent, mechanical ruggedness may be realized without serious loss in strength by: 1. Metal cladding which is effective in absorbing energy locally from a high-velocity small-mass impact load. 2. Laminating low-metal cermet layers with alternate layers of pure metal so that macroscopic volumes of metal in the layers can deform plastically.

AIChE Preprint 48, presented at the Forty-Second National Meeting, Atlanta, Ga., February, 1960, 9 pp.

Rolling-Contact Fatigue Life Of High-Temperature Steels

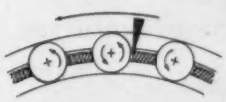
Thomas L. Carter, Erwin V. Zaretsky, and William J. Anderson, Lewis Research Center, NASA.

Effect of hardness and other mechanical properties on rolling-contact fatigue life of four high-temperature bearing steels. Tests have been made at room temperature on groups of AISI M-1, AISI M-50, Halmo, and WB-49 alloy-steel balls tempered to various hardness levels. Observations are:

1. Rolling-contact fatigue life and

The superbly designed RBC PITCHLIGN Roller Bearing's CAGE-ROLLER COMBINATION provides...

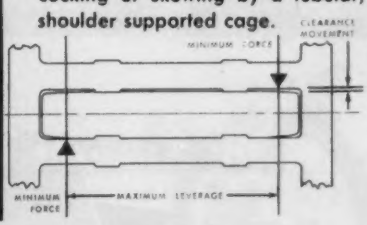
ABSOLUTE ROLLER ALIGNMENT • PITCH LINE ROLLER GUIDANCE • FULL LENGTH ROLLER CONTROL • AMPLE STORAGE SPACE FOR LUBRICANT • EQUAL COEFFICIENT OF EXPANSION • TUBULAR CAGE • PARALLEL SIDES ON ROLLER WINDOWS • MINIMUM FRICTION BETWEEN CAGE AND ROLLER



Each roller is free to compress under load without cramping adjacent rollers. Space between rollers essential for lubricant storage. Cage, race and rollers have same coefficient of expansion.

Aligning rollers at their pitch circle requires minimum of cage effort, but produces maximum effect because all forces are direct.

Full length control keeps rollers in axial alignment with shaft and race indispensable for uniform load distribution. Rollers are prevented from cocking or skewing by a tubular, shoulder supported cage.



Let RBC Engineers help you remove the friction from your design problems . . . Insist on the best—The Pioneering PITCHLIGN.

ROLLER BEARING COMPANY OF AMERICA
Sullivan Way, West Trenton, New Jersey

Circle 533 on Page 19

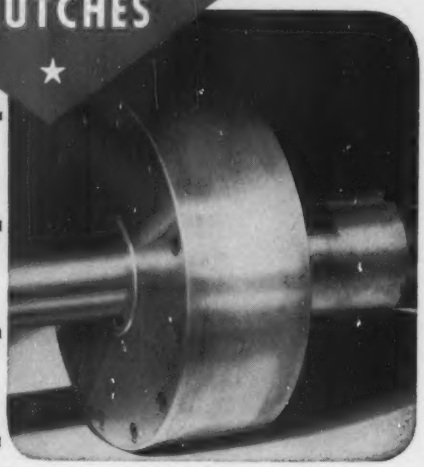
FOR POWER CONTROL DESIGNS USE
HILLIARD
Over-Running
CLUTCHES

1 LONG LIFE because the rolls have no localized wear points.

2 NO JAMMING even after long wear.

3 ACCURATE because of individual spring pressure on each roll.

4 RENEWABLE CAM SURFACES for increased life without machining or new parts.



50 YEARS of satisfactory service proves you can depend on Hilliard Over-Running Clutches and Couplings for long service on—

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- RATCHET ACTION for printing press ink rolls, coal feeders, press feeds, honing machines, bakery equipment and conveyors.
- BACK STOP SERVICE on textile machines, speed reducers, elevating conveyors and in combination with ratchet feeds.
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load-carrying capacity of each alloy increase with higher material hardness. The improvement in load capacity was in the order of 30 to 100 per cent over the hardness range tested. No maximum fatigue life or load capacity at intermediate hardness values was observed.

2. These fatigue results did not correlate with previously published tension and compression strength results for bar specimens from the same heats of material. Bar specimens showed an apparent optimum strength at intermediate hardness values.

3. Resistance to permanent plastic deformation of specimens in rolling contact showed a general increase with increasing hardness.

NASA Technical Note D-270, *Washington, D. C., March,* 1960, 51 *pp.*

Geometric Blending Of Plastic Contours

William Deane Evans, Estee Mold & Die, Inc.

How to obtain uniformly graduated wall thicknesses in plastic products formed in molds. One method is to form contours of a number of circular arcs each of which is tangential to adjacent arcs. Where the product is intended to transmit light in uniformly graduated intensity, noticeable changes in intensity occur at the junctions of arcs. These points are called "blends." Refinement of blends requires inside and outside contours which have uniform rate of change of radius, hence uniformly changing wall thickness. Refinement of contour is accomplished by application of the Archimedian spiral. A base line is introduced to assure that spiral blending prevails in three dimensions.

In addition to this use of blending, other applications are:

1. Uniform distribution of structural stresses from one part element to another.

2. Reduction of fatigue failure in parts to which cyclical, repeated stresses are applied.

3. Reduction of internal casting stresses caused by the difference in cure time between light and heavy sections.

4. Smoothness of the surfaces for both appearance values and the

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Circle 535 on Page 19

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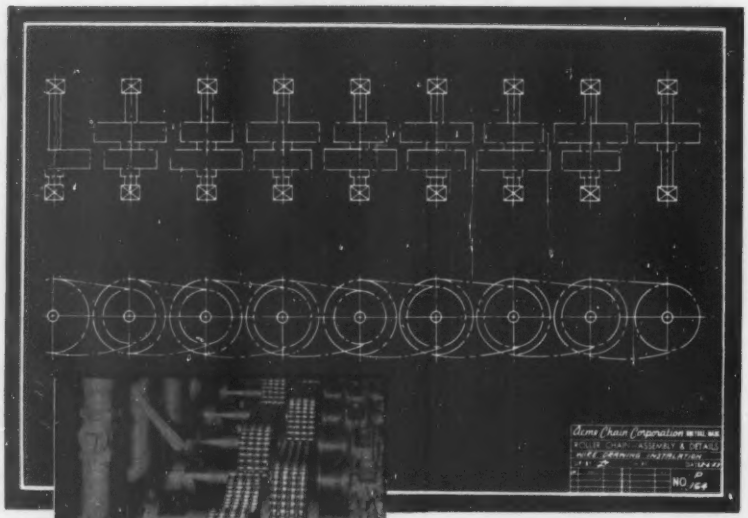

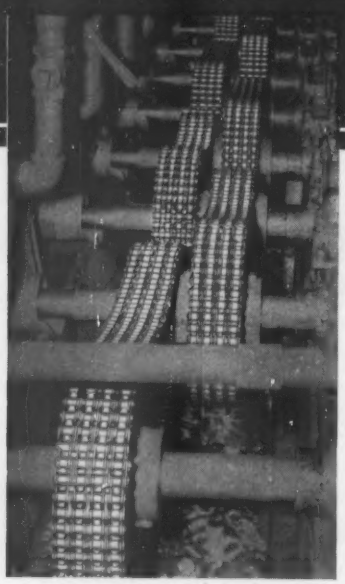

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functions which the parts must perform, such as ease of cleaning in parts used with foods.

SPE paper 60, presented at the 16th Annual Technical Conference of the Society of Plastics Engineers, Inc., Chicago, January, 1960, 3 pp.

Glass-Reinforced Plastic Structures

Lawrence Fischer, structural development engineer, Grumman Aircraft Engineering Corp.

A mathematical procedure for analyzing stresses and strains in a laminate composed of one or more layers of fiberglass and subjected to axial and shear stresses applied in the plane of the laminate. A layer of fiberglass is assumed to behave structurally as an orthotropic material.* On that basis, stresss-strain relationships are determined for a single layer, then used for distribution in a laminate of many layers.

SPI paper 3-D, presented at the 15th Annual Meeting of the Reinforced Plastics Div., Society of the Plastics Industry, Inc., Chicago, February, 1960, 11 pp.

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AIChE—American Institute of Chemical Engineers, 25 West 45th St., New York 36, N. Y., papers 50 cents.

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ASTME—American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave., Detroit 38, Mich.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W. 1, England.

NASA—National Aeronautics and Space Agency, 1520 H St., N.W., Washington, D. C.

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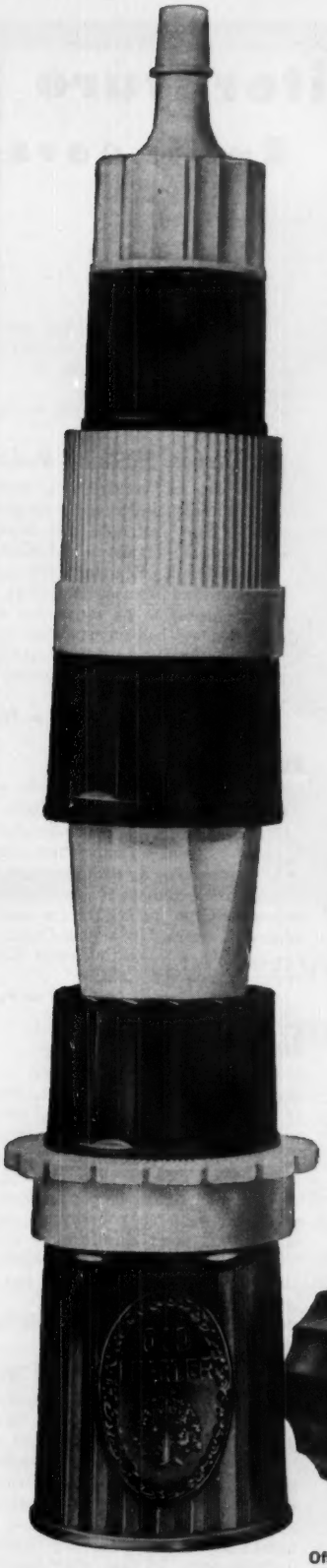
SPE—Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn., papers 25 cents to members, 40 cents to nonmembers.

SPEctator Editorial Office, Somers, Conn., copies 25 cents to nonsubscribers.

SPI—Society of the Plastics Industry, Inc., 250 Park Ave., New York 17, N. Y.

Westinghouse Engineer, P. O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa.

Engineering Materials and Design Conference, organized by Industrial and Trade Fairs, Ltd., Drury House, Russell St., London, W.C. 1, England.



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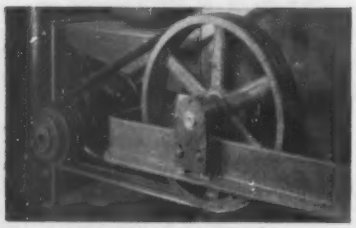
Circle 537 on Page 19

WOOD'S POWER TRANSMISSION PRODUCT NEWS



NEW, NON-FREEZING VARIABLE

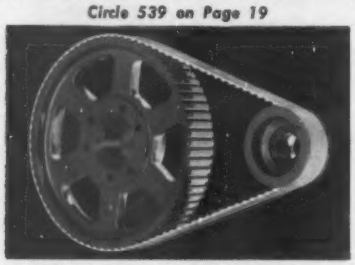
Wood's new "SVS" stationary control, variable speed drive has positive locking collars and other, patented features which eliminate freezing, assure easy speed change. No lubrication is required. Uses standard v-belts and stock companion sheaves. Write for Bulletin 6102.

Circle 538 on Page 19

NEW, TREMENDOUS SAVINGS

Wood's new Ultra-V Drives handle up to 3 times more horsepower than conventional v-belt drives in a given space... reduce overall drive dimensions as much as 50%... cut weight up to 25% and costs up to 30%. Write for Bulletin 9102.

Circle 539 on Page 19



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Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Miniature Bearings

Design Catalog 60-01 is an illustrated guide for the selection of Microspin miniature precision instrument bearings. Design features, available styles and sizes, specifications, applications, and installation procedures are presented. Also included is a simplified method of determining allowable bearing loads for any size bearing and any shaft speed by using a precalculated load-speed rating. 4 pages. Northfield Precision Instrument Corp., 4400 Austin Blvd., Island Park, L. I., N. Y.

Circle 701 on Page 19

Fractional-Horsepower Motors

Benefits and features of fractional-horsepower Form-G general-purpose motors are discussed in Bulletin GEA-6424A. Capacitor-start, split-phase, permanent-split capacitor, shaded-pole, and polyphase motors are included. Sixteen kinds of fhp motors, ranging from motors for machine tools to room airconditioner motors, are shown in NEMA frame sizes 48 through 56. 12 pages. General Electric Co., Schenectady 5, N. Y.

Circle 702 on Page 19

Expanded Metals

Micromesh small expanded-metal meshes of ductile materials, including precious metals, are described in Form 100 booklet. Uses of the materials are given and chart lists minimum and maximum dimensions available. 4 pages. North American Cement Corp., Designers Metal Div., 650 Hoffman St., Hammond, Ind.

Circle 703 on Page 19

Potentiometer Selection

Precision potentiometer selector chart, measuring 24 x 30 in., is suitable for wall mounting. It contains complete, easily read specifications, including electrical, mechanical, mounting, special features, and environmental information on 37 standard models of single and multiturn precision potentiometers. Spectrol Electronics Corp., 1710 S. Del Mar Ave., San Gabriel, Calif.

Circle 704 on Page 19

Polycarbonate Resin

Physical and electrical properties of Merlon polycarbonate resin, a new thermoplastic for engineering applications, are listed in Technical Information Bulletin 41-M1. Material is compared with seven other plastics to show the combination of characteristics which makes it suitable for use in the electrical, automotive, lighting, general industrial, graphic arts, and engineering fields. 6 pages. Mobay Products Co., 1815 Washington Rd., Pittsburgh 34, Pa.

Circle 705 on Page 19

Balls, Shapes, Finishing Media

Advantages of construction, performance, and adaptability of bearing balls, metals-finishing materials, and decorative steel shapes are discussed and illustrated in Bulletin AP-1. Representative applications, size and dimensional data, and tabular information on conversion of old Abbott standard ball nomenclature to new AFBMA nomenclature are included. 4 pages. Abbott Ball Co., 29 Railroad Ave., Hartford 10, Conn.

Circle 706 on Page 19

Rotary Seals

Precision bellows rotary shaft seals—types, sizes, special alloys available, and typical installation diagrams—are described in new bulletin. Temperature range is −400 to +1200 F, with pressure range from absolute zero to 500 psi for formed bellows and to 10,000 psi for machined bellows. 4 pages. Hydrodyne Corp., Skinner Seal Div., 7350 Coldwater Canyon, North Hollywood, Calif.

Circle 707 on Page 19

Electrical Relays

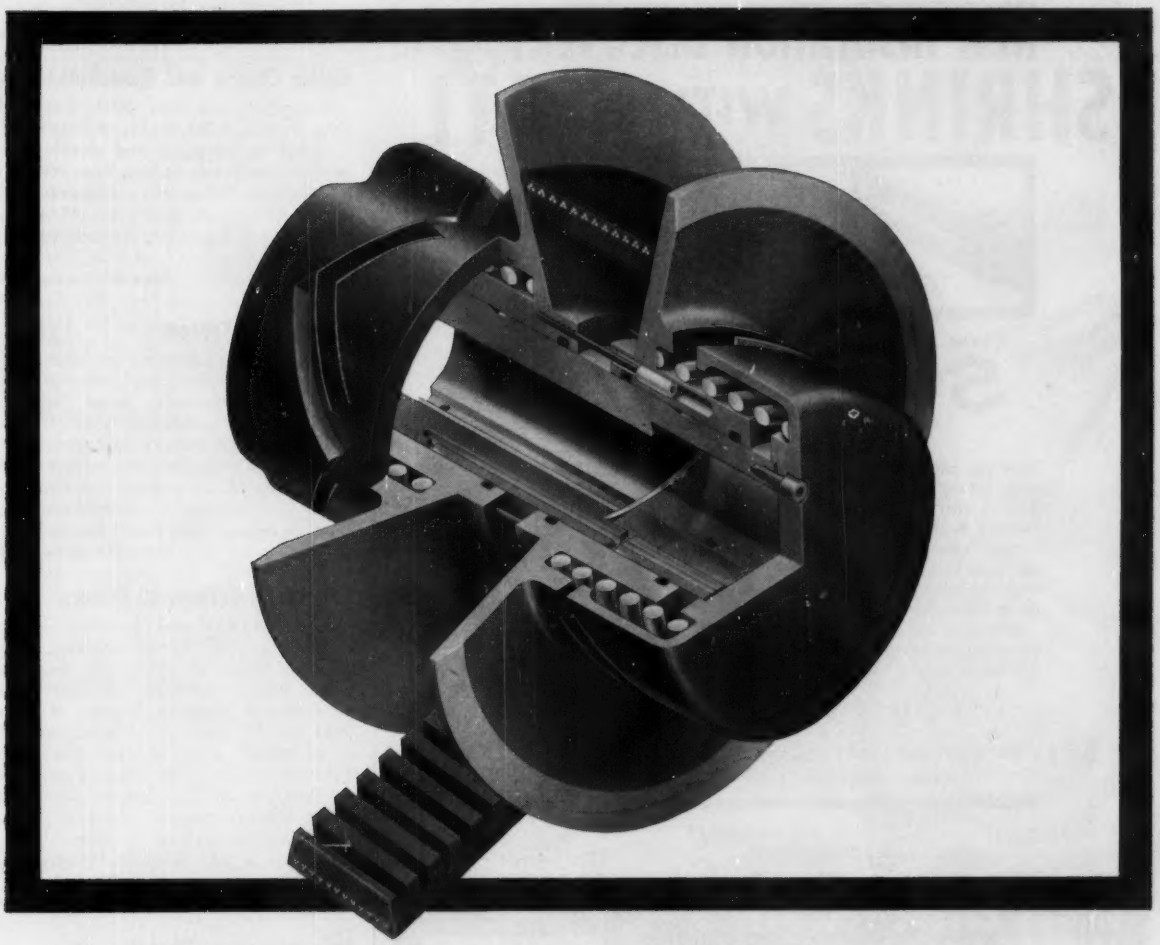
Available for communications, computers, industry, and military use, 30 types of relays in many variations are presented in new relay manual. Using photographs, line drawings, tables, and descriptive material, publication presents data on pile-up type relays. Variations in spring arrangement, timing, coil voltage, contact ratings, and other classifications are outlined. 45 pages. Cook Electric Co., Diaphlex Div., 2700 Southport Ave., Chicago 14, Ill.

Circle 708 on Page 19

Vacuum Metallizing Coatings

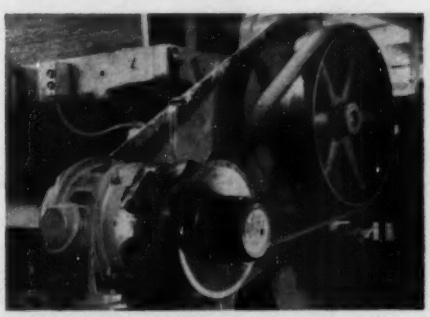
Comprehensive booklet, "Coatings for Vacuum Metallizing," describes in detail the application and use of vacuum metallizing coatings which can be applied by spraying, dipping, and flow coating to thermoplastics, thermosetting plastics, metals, and glass. Base coats for use before metallizing, as well as top coats and back-up coats for use after metallizing, are discussed. 45 pages. Bee Chemical Co., Logo Div., 12933 S. Stony Island Ave., Chicago 33, Ill.

Circle 709 on Page 19



New, revolutionary "MCS" sheaves won't freeze, hold constant speeds

Wood's "MCS" motion control, variable speed sheave is entirely new and revolutionary in concept. It holds constant driven speeds under varying torque loads. And, like Wood's recently introduced "MS" sheave, the "MCS" won't freeze or stick. Practically no maintenance is required. No more downtime, running through the speed range or dismantling. The oil reservoir requires checking only once or twice a year. These amazing advantages are made possible by Wood's exclusive, resilient cam follower construction and rotational oil pumping action. Investigate these and many other features. Write for Bulletins 8102 and 4101.



Wood's "MS" variable speed sheave is similar in basic operating principle to the "MCS." Power is transmitted through resilient keys which are externally located, permitting unobstructed lubrication, elimination of freezing and sticking.

Woods

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Circle 541 on Page 19

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PRODUCT RESEARCH

Circle 543 on Page 19

HELPFUL LITERATURE

Roller Chains and Sprockets

Book 2757 lists over 2000 types and sizes of stock roller chains and sprockets. Included are standard and double-pitch power-transmission chains, large selection of conveyor chains and attachments, and complete line of sprockets. 44 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 710 on Page 19

Computing System

Brochure S-483 describes precision RPC-4000 electronic computing system, a fully transistorized, electronic, stored program, general-purpose computing system for both engineering and business-data processing. Brochure gives specifications, describes the components of the system, and lists applications. 6 pages. Royal McBee Corp., Data Processing Div., Port Chester, N. Y.

Circle 711 on Page 19

Solenoids, Selectors, Motors

Illustrated with line drawings, charts, photographs, and circuit diagrams, Bulletin A-1259 is an application guide to Ledex rotary solenoids, selectors, and Syncramental stepping motors. It contains specific physical, performance, and environmental data on more than 250 different models. Information is provided on how to use the data to select the proper solenoid, selector, or stepping motor for any application. 8 pages. G. H. Leland Inc., 123 Webster St., Dayton, Ohio.

Circle 712 on Page 19

Polypropylene Thermoplastic

Technical booklet on Pro-fax polypropylene provides information on physical characteristics, mechanical properties, chemical resistance, electrical properties, and on injection molding, extrusion, and fabrication. Form 500-302C is supplemented with tables, charts, photographs, and descriptions of commercial applications. Various types of Pro-fax packaging and shipping data, and bibliography of other information on polypropylene, are included. 20 pages. Hercules Powder Co., Wilmington 99, Del.

Circle 713 on Page 19

Permanent-Magnet Pulleys

Bulletin 1022 furnishes data and specifications on the complete line of Indox V pulleys in sizes from 12 to 48-in. diam. Easy-to-use selection chart permits specifying the correct pulley for any system. 6 pages. Stearns Magnetic Products, 635 S. 28th St., Milwaukee 46, Wis.

Circle 714 on Page 19

Electric Controls

Standard, special, and custom controls used to actuate Warner electric brakes and clutches are described in Form P-75 brochure. Included are sections on operation, dimensions, and selection. 8 pages. Warner Electric Brake & Clutch Co., P-75, Beloit, Wis.

Circle 715 on Page 19

Servo Motors

Complete with typical unit characteristics, specifications, dimensions, and torque-speed curves, new catalog describes line of Size 18 servo motors. Components include Size 18 servo motors and servo motor-rate generators for 115-v, 60 or 400-cycle operation, as well as an inertia-damp unit for 115-v, 400-cycle operation. Specification check list is furnished for use if special units are required. 16 pages. Beckman Instruments Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle 716 on Page 19

Pendent Switches

Nine new pendent switches for electric hoist control are encased in corrosion-proof, shock-resistant, watertight Hycar synthetic rubber. Fold-back in one page of Bulletin 79 provides a quick front, back, and interior view of the station. 8 pages. Joy Mfg. Co., Electrical Products Div., 1201 Macklind Ave., St. Louis 10, Mo.

Circle 717 on Page 19

Corrosion Resistance Guide

New guide lists relative ability of metals, plastics, and synthetic rubbers used in the manufacture of Flo-Ball valves to resist the corrosive effects of 390 different fluids encountered in industry. Introduction provides a cross-section of the valve and the chemical composition of the metals used in its construction. Physical characteristics and temperature range of the plastics and synthetic rubbers are also provided. 8 pages. Hydromatics Inc., 70 Okner Parkway, Livingston, N. J.

Circle 718 on Page 19

Gear Motors and Reducers

Features of Slo-Speed gear motors and separate motor reducers are presented in Bulletin 198. Also included are basic types and many modifications, as well as the universal mounting positions in which the units can be used. 8 pages. Sterling Electric Motors, 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 719 on Page 19

Socket Screws

Form 2335 technical reference on industrial socket screws, titled "Unbrako Socket Screw Catalog and Engineering Standards," covers more than 2800 items. Three sections incorporate: Basic information on size, material, and availability, in tabular form; section of basic design and performance information; and a simplified technology of fasteners. 82 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 720 on Page 19

Nylon Bobbins and Washers

Bulletin BW1259 provides illustrations and descriptions of nylon bobbins and thrust washers. Complete size specifications are given. 4 pages. Cosmo Plastics Co., 3239 W. 14th St., Cleveland 9, Ohio.

Circle 721 on Page 19

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Circle 544 on Page 19

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per thousand pieces

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Circle 545 on Page 19

Photoelectric Scanner

Type SA-IR photoelectric scanner which contains both light source and pick-up head in one small housing is completely described in Bulletin 260. Details include photographs, dimensions, size and mounting specifications, delivery, and prices. 1 page. Farmer Electric Products Co. Inc., 2300 Washington St., Newton Lower Falls, Mass.

Circle 722 on Page 19

Solenoid-Operated Cylinder

Lightweight, compact, solenoid-operated cylinder for air, oil, or water operation is detailed in Bulletin 458. The 1⅛-in. bore cylinder, know as the Valv-N-Hed series, is available in 1, 2, and 3-in. strokes. Bulletin provides information on construction features, dimensions, and accessories. 6 pages. Sheffer Corp., 320 W. Wyoming Ave., Cincinnati 15, Ohio.

Circle 723 on Page 19

Gasketing and Gaskets

Palmetto line of gasketing and gaskets for flanges, joints, boiler manholes, furnace doors, and similar applications is described and illustrated in Catalog GG-1259. Extensive data supplied for each type of sheet or other packing includes details on composition, temperature limits, and services for which it is designed, plus complete tabular listings on thicknesses, lengths, weights, standard packagings, and prices. 12 pages. Greene, Tweed & Co., North Wales, Pa.

Circle 724 on Page 19

RF Connector Selection

Two-color brochure is a guide to the selection of RF connectors by RG cable types. It includes a cross reference of cables versus applicable connectors, and a guide for adapters between series. Category definitions indicate current preferences over obsolescent components and preferred replacement in RF transmission-line applications. 4 pages. Schweber Electronics, 60 Herricks Rd., Mineola, L. I., N. Y.

Circle 725 on Page 19

Diaphragm Seals

Available for the protection of pressure instruments against corrosion and clogging, Brookseal diaphragm seals are described in Bulletin 250. Catalog contains full descriptions, specifications, and prices of all models. 24 pages. Brooks Rotameter Co., P. O. Box 432, Lansdale, Pa.

Circle 726 on Page 19

Lock and Weld Nuts

New products catalog lists lines of lock nuts, weld nuts, and semifinished nuts. Each type is illustrated, and includes description and specification data. Uni-Torque, Two-Way, and Whiz-Lock nuts are included. 8 pages. MacLean-Fogg Lock Nut Co., 5535 N. Wolcott Ave., Chicago 40, Ill.

Circle 727 on Page 19

Yours for the asking

This "Diamond H"
Checklist of
Reliable Controls

. . . Relays, Thermostats, Switches . . . engineered to meet your specific requirements in a wide variety of applications including air conditioning, appliances, aircraft, missiles, machine tools, panel boards, heater and motor control circuits, and many others.

• • •

Ask also for our new application data sheets on Series R and Series W Relays, and Rotary Switches.

THE HART
MANUFACTURING COMPANY
118 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

Circle 546 on Page 19

NEW *EMRALON*® TFE COATINGS SOLVE HEAT SENSITIVE APPLICATIONS

Acheson's resin-bonded tetrafluoroethylene (TFE) surface coatings are finding ready acceptance among design engineers. Where previous limitations of pure TFE prevented its application on heat sensitive substrates, because of its 700° F. sintering temperature, 'EMRALON' coatings are being successfully used on rubber, light metals, woods, and plastic. One such impressive case history is outlined here.

'EMRALON' coating is shown being spray-applied on woven belting with conventional equipment.

OVER $15,000.00 ANNUAL SAVINGS PROJECTED BY PROMINENT TIRE MANUFACTURER

Dunlop Tire and Rubber Corporation, Buffalo, N. Y., estimates this considerable savings in down-time costs alone on the basis of nearly nine months production use of an 'EMRALON'-coated belt conveyor. The particular belt involved is thirty feet long. Its importance in this company's tire production is emphasized by the fact that it is located at the point of a previous bottleneck. Rubber strips, conveyed from a series of masticating mills to an extruding press, formerly became stuck to the belting of this short-run conveyor immediately above the final masticator. The reason: the temperature of the rubber is elevated — through friction of the masticating process — to between 150° F. and 300° F. at this point. Belts had to be replaced anywhere from once every several hours to every six weeks. It was not unusual to have two or three stoppages every shift. The result: with the supply of rubber temporarily cut off, the entire department shut down. Costs ran $5.00 a minute, and with these work stoppages averaging 20 minutes each, the accumulated expense became prohibitive. Since April, 1959, the new belt has been in constant operation at this critical point in the masticating line.

To date it has not been removed from the mill . . . ample proof of the extraordinary non-stick, adhesion and flexing qualities of its 'EMRALON' coating!

The woven conveyor belt is a product of Globe Woven Belting Company, Buffalo, N.Y. Application of Acheson's 'EMRALON' to their belting was the outcome of a continuing research program headed by Globe Research Manager, Fred Kohlhagen. It is applied by standard commercial spray equipment to a film thickness of 0.7 mils and then oven-cured at a temperature of 300° F.

According to Mr. Kohlhagen, "This example will be only one of many success stories told about this coating. 'EMRALON'-coated belting can be used anywhere a slick, non-corrosive belting is needed. Those in the baking, canning, food processing, food packaging, and rubber fields should find immediate use for it." We might add that there are many other industries finding it advantageous to use 'EMRALON' . . . yours quite possibly is one of them. Why not write today for further information?

'EMRALON' — coated conveyor belt carrying hot rubber through masticating mill.

'dag' is a trademark registered in the U. S. Patent office by Acheson Industries, Inc.

'EMRALON' ADVANTAGES PROVED IN MANY LIGHT-LOAD USES

The growing list of production applications for the new Acheson 'EMRALON' surface coatings, is convincing proof of their versatility. That film pack, office machine, and lock mechanisms; rubber molds and oil seals; bakery dough handling equipment and countless other light load, solid-film lubrication problems have successfully been answered, is now a matter of record.

With 'EMRALON' 310* — colloidal TFE in a phenolic resin solution — a one-hour cure at 300° F. is all that is necessary. And, for substrates even more sensitive to heat, 'EMRALON' 320** colloidal TFE in a thermo-plastic resin carrier — is available. Both provide excellent adhesion, low coefficient of friction, flexibility, toughness, and corrosion resistance. Applied by conventional paint spray equipment, they allow easy production line conversion to 'EMRALON' solid-film lubricants.

'EMRALON' coatings represent the latest in a long line of widely accepted Acheson products, one of which may offer a ready-made answer to your particular lubrication problem. We welcome the opportunity to be of service. Send for your copy of our Products List which outlines the full line of Acheson Dispersions. Address Dept. MD-40.

*'EMRALON' 310 is manufactured under exclusive license from E. I. duPont deNemours & Company (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.

**'EMRALON' 320 — patent applied for.

ACHESON

dispersions digest reporting uses for

dag BRAND DISPERSIONS

ACHESON **ACHESON** *Colloids Company* PORT HURON, MICHIGAN

A division of Acheson Industries, Inc. Also Acheson Industries (Europe) Ltd. and affiliates, London, England

Offices In:

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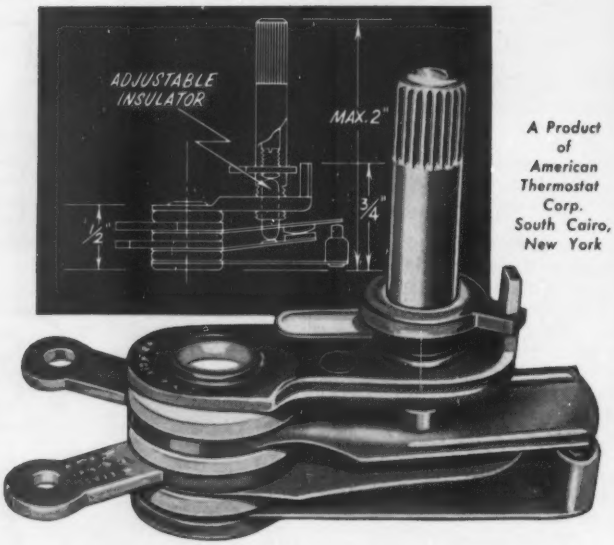
Circle 547 on Page 19

Chace THERMOSTATIC BIMETAL

Actuates Another Precision Product

THE ATC **american**

MODEL A-7
THERMOSTAT



A Product of American Thermostat Corp. South Cairo, New York

This compact, adjustable thermostat is used by manufacturers of bakers, coffee makers, deep fryers, roasters, solder cups, sealing machines, water heaters and other appliances and industrial and laboratory devices. It is precision assembled for uniformity of calibration range and is so constructed that the bimetal element is not subjected to mechanical stress after disconnection if the thermostat is left "On" at high heat. The heavy-walled rivet eliminates calibration change due to mounting pressure and the silver contacts are welded to stainless steel springs. Other features: trimmer set screw, single screw mounting, rigid control bracket for permanent alignment. The useful range for which units can be supplied calibrated is from 70° to 600° F. Ratings: AC, to 230 v., 1650 w.

"Uniformity" has long been a watchword at Chace because it is uniformity of bimetal performance that saves millions of users of appliances and other temperature-actuated devices from the annoyances and dangers of unpredictable waffles, scorched deep-fat, overheated solder and the like. And the many "uniformities" in Chace Thermostatic Bimetal are the result of over a third of a century of research and development, of advanced processes, of constantly improved precision equipment and of relentless testing and inspection. Add to all this the well-known Chace integrity and you'll know why your name is safe on the outside with Chace bimetal inside.

Remember, Chace bimetal is available in coils, strips and completely fabricated elements of your design. Send now for "Successful Applications of Chace Thermostatic Bimetal" containing many pages of valuable design data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Aircraft Fasteners

Catalog 600 is a guide to the selection of precision bolts and special fasteners for the aircraft, missile, and avionic industries. Catalog includes 18 pages of AN and NAS aircraft bolt standards. An additional 12 pages of availability charts reference AN and NAS hexhead bolts, NAS external and internal wrenching bolts, close-head tolerance, corrosion-resistant bolts, and A286 nonmagnetic, aircraft-quality bolts. 40 pages. Aircraft Bolt Corp., 543 Monterey Pass Rd., Monterey Park, Calif.

Circle 728 on Page 19

Torque Converter

Described in Form N1-9, air-cooled torque converter is intended for applications such as small road rollers and construction machines, tractors and agricultural equipment, other vehicles, and industrial power transmission. Specifications include typical performance curve, dimensioned exterior drawings, and cutaway section. 4 pages. Clark Equipment Co., Automotive Div., Jackson, Mich.

Circle 729 on Page 19

Precision Spindles

Pocket-sized Bulletin S-18 illustrates and describes over 60 different precision spindles for grinding, boring, milling, slotting, and drilling. Also featured is new line of custom-built driving motors. 36 pages. Pope Machinery Corp., 261 River St., Haverhill, Mass.

Circle 730 on Page 19

Germanium Transistors

New Catalog AO1 covers 412 germanium transistor types for applications in computers, aircraft, missiles, military, marine, entertainment, and general industry. All transistors are manufactured to registered EIA specifications. 4 pages. Electronic Transistors Corp., 9226 Hudson Blvd., North Bergen, N. J.

Circle 731 on Page 19

High-Temperature Alloy

Technical Data Booklet 52-263 contains general information on applications, metallurgical characteristics, physical properties, mechanical properties, creep and creep-rupture properties, availability, and material processing of W-545 vacuum-melted high-temperature alloy. Photomicrographs show structures of the material, and many tables and graphs illustrate its properties. 12 pages. Westinghouse Electric Corp., Metals Plant, Blairsville, Pa.

Circle 732 on Page 19

Electrical Relays

Catalog 160 provides information on a complete line of telephone-type, hermetically sealed telephone-type, and microminiature crystal-can relays. Illustrations, specifications, and dimensional diagrams cover a variety of relay types. 24 pages. Magnecraft Electric Co., 3250 W. Grand Ave., Chicago 51, Ill.

Circle 733 on Page 19

Circle 548 on Page 19

Automatic Flow Control

Mesurflo automatic flow controls for original equipment applications are described in new brochure. Line features low pressure drop and a wide variety of flow rates from 2/10 to 50 gpm. Bulletin provides construction information, sizes, flow chart, and examples of applications. 6 pages. Hays Mfg. Co., Automatic Controls Div., 803 W. 12th St., Erie, Pa.

Circle 734 on Page 19

Sheaves and Motor Bases

Catalog SL-101-A illustrates and describes line of spring-loaded and manually controlled variable-pitch sheaves and adjustable motor bases. In addition to illustrations and specifications, catalog contains tables of practical stock drive combinations for convenient selection. 8 pages. Browning Mfg. Co., Maysville, Ky.

Circle 735 on Page 19

Steel Tubing

Bulletin CS-60 provides technical information on seamless tubing for mechanical and aircraft use, on welded tubing for mechanical and pressure use, and on fabricated and forged tubing. Tables list dimensions, tolerances, aeronautical specifications, sizes, and straightness. 8 pages. Copperweld Steel Co., Ohio Seamless Tube Div., Shelby, Ohio.

Circle 736 on Page 19

Technical Fountain Pen

New model Rapidograph nonclogging technical fountain pen is described in pocket-sized folder. Pen has seven individually interchangeable drawing point sections, each with its own refillable ink cartridge. 4 pages. Koh-I-Noor Pencil Co., Bloomsbury 6, N. J.

Circle 737 on Page 19

Stainless-Steel Filters

Information on multiple-surface, porous stainless-steel filters which meet a wide range of flow rates, temperatures, pressures, and slurries, is provided in Release M-208A. Several new filter types and sizes are described, as well as typical filter aid set-ups. Full engineering data is given on the steel, including method of manufacture, particle size removal, flow rates, working, and welding. 8 pages. Pall Corp., Micro Metallic Div., 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 738 on Page 19

Aluminum Alloys

New booklet, "Olin Aluminum Mill Products," describes physical properties, fabrication characteristics, and economic advantages of a wide variety of aluminum sheet, plate, rod, bar, extrusion, and casting alloys. Information on specialty sheet products, bus conductor, mine and oil-country pipe, and architectural shapes, is included. 24 pages. Olin Mathieson Chemical Corp., Metals Div., 400 Park Ave., New York 22, N. Y.

Circle 739 on Page 19

How DPS elevating feeders elevate, orient, feed your parts to cut production costs

New elevating feeders from Detroit Power Screwdriver Company—

- Eliminate hand feeding
- Permit high-speed feeding and orienting
- Discharge parts at height to suit your requirements
- Offer adequate holding capacity

The output of hand-fed production machinery soars with DPS elevating feeders. Parts of almost any size, shape and material can be fed quickly, gently, in a continuous flow to other machinery for processing and assembly.

Three standard sizes available: 6, 12 and 20 cu. ft. holding capacities. Larger or smaller units can be fabricated to meet special requirements.

NEW BULLETIN
. . . has complete information on new DPS elevating feeders. Mail the coupon today!

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DETROIT POWER SCREWDRIVER COMPANY
2801 W. Fort St., Detroit 16, Michigan

Send new Elevating Feeder Folder 2812.

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ADDRESS_____

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Circle 549 on Page 19

HIGH
TEMPERATURES?
COMPOUNDS
EFFECTIVE TO
+550°F
TECHNICAL MEMO ON LINEAR COMPOUNDS
8251-70—8250-85—8252-90
. . . outstanding for O-Rings, V-Rings and U-Cups.
• truly effective sealing at temperatures to +550°F
• suitable for use with a wide variety of fluids, including oils, fuels, water and diverse chemicals
• good resistance to compression set and wear
FLUIDS COMPATIBLE WITH THESE COMPOUNDS
Acetone • Acetylene Tetrabromide • Air • Amyl Alcohol
Aniline • Arochlor 1248 • Benzine • Carbon Disulfide • Carbon
Tetrachloride • Chloroform • Cyclohexane • Dowtherm A
Styrene • Sulfuric Acid • Toluene • Benzol • Dry Chlorine Gas
Ethyl Alcohol • Ethylene Dichloride • Ethylene Glycol • Gasoline
GE 81406 • Hexane • Isobutyl Alcohol • JP-4 and JP-5 Fuels
Kerosene • Methylene Dichloride • Trichloroethylene • Turpentine • Water • MIL-F-25558A Fuel • MIL-L-7808 Lubricants
MIL-O-5606 Hyd. Fluid • MLO-8200 Hyd. Fluid • MLO-8515
Hyd. Fluid • Naphtha • Nitrogen • OS 45-1 Hyd. Fluid • Petroleum Base Oils • Silicone Fluids • Steam • Wet Chlorine Gas
For complete technical data—including list of incompatible fluids, request Bulletin 56700-1. Linear Inc., State Road and Levick St., Philadelphia 35, Pa.
PERFECTION IN RUBBER
LINEAR
LINEAR Inc. STATE ROAD & LEVICK ST. PHILA 35 PA.

Magnetic Starters

Publication PL-12-8-160 gives engineering data on Type CY magnetic starters. Available in a full range of sizes from 0 through 4, starters feature sturdy construction, simplicity of design, and fast, easy maintenance. Arc-quenching principle, which provides high contact life under heavy current loads and severe arcing conditions, is fully described and diagrammed. Enclosures, forms, and combinations of starters for every industrial requirement are shown. 8 pages. Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.

Circle 740 on Page 19

Ball Bearing

Engineering Data Sheet T-1 describes T-retainer bearing, providing information on applications, performance, load capacity, materials, tolerances, and radial play. Table furnishes availability and dimension data. 4 pages. Barden Corp., 200 Park Ave. Danbury, Conn.

Circle 741 on Page 19

Pressure Gages

Type 110 Gearcoid gages, pressure instruments designed for a wide range of industrial applications, are described in Bulletin DH-333. Gages, which feature a geared movement, are recommended for oil, air, water, steam, gas, or any other media not corrosive to brass or bronze. Engineering data showing details of construction, outstanding features, applications, specifications, pressure ranges, and dimensions, are listed for easy reference. 4 pages. American Chain & Cable Co. Inc., Helicoid Gage Div., 929 Connecticut Ave., Bridgeport 2, Conn.

Circle 742 on Page 19

Nonferrous Metal Powder Parts

Titled "Designing for Pressed-Brass and Nickel-Silver Metal-Powder Parts," new booklet is available to design engineers and manufacturers. First section contains information on the powder-metal process and its uses in modern production techniques. Applications section contains pictures and case-history information on 27 examples showing the uses of brass and nickel-silver metal-powder parts in different types of products. 24 pages. New Jersey Zinc Co., 160 Front St., New York 38, N. Y.

Circle 743 on Page 19

Cases and Housings

Comprehensive catalog on military cases, portable cases, transit cases, and housings lists available sizes, shapes, and metals, as well as construction details. Also listed are typical products, including panels, dustcovers, aircraft cowlings, and engine parts. Sample vellums inserted into the catalog detail constructions for combination, transit, storage, and 19-in. rack equipment cases. 4 pages. MM Enclosures Inc., 111 Bloomingdale Rd., Hicksville, L. I., N. Y.

Circle 744 on Page 19

Circle 550 on Page 19

Precision Electrical Instruments

New color brochure, "World Standards," describes precision electrical instruments for use as laboratory standards for aircraft and missile development, public utilities, and most standards laboratories. Brochure details and diagrams each major component, including: Voltmeters and ammeters; ac or ac-dc voltmeters, ammeters, and wattmeters; current transformers; low and high-voltage potential transformers. 24 pages. Daystrom Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N. J.

Circle 745 on Page 19

High-Alloy Designation

Pocket-sized revision of list of standard designations and chemical composition ranges for heat and corrosion-resistant cast alloys is now available. List includes 32 grades, two of which are new corrosion-resistant alloys designated CD-4MCu and CG-8M. The former is a precipitation-hardening stainless alloy which provides double the strength of 18-8 stainless with equal or better corrosion resistance. Type CG-8M is a higher molybdenum modification of CF-8M grade. 4 pages. Alloy Casting Institute, 1001 Franklin Ave., Garden City, N. Y.

Circle 746 on Page 19

Metering Pumps

Catalog 59 describes the use of Pulsafeeder metering pumps in many process industries. Catalog includes information on how the units are used, types of hard-to-pump fluids which they handle, detailed description with illustrations on how the meters work, and various reagent heads available for effective metering of difficult fluids. Two pages of tables detail capacities, sizes, and specifications on the various types of meters. 28 pages. Lapp Insulator Co. Inc., Process Equipment Div., 112 Hall St., LeRoy, N. Y.

Circle 747 on Page 19

Wire and Cable Terminology

Pocket-sized "Glossary of Wire and Cable Terms" lists in alphabetical order common terms, expressions, and units used in the electrical wire and cable industry. It is available as a reference to engineers, designers, technicians, and purchasing personnel. 52 pages. Request on company letterhead from Standard Wire & Cable Co., 3440 Overland Ave., Los Angeles, Calif.

Estimating Casting Weights

Greater accuracy in estimating weights of cast-aluminum parts can be achieved through use of new booklet, "How Aluminum Foundries Estimate Casting Weights." Booklet outlines procedures employed in computing weights, and includes numerous tables, engineering drawings, and formulas. 16 pages. Write on company letterhead to The Aluminum Association, 420 Lexington Ave., New York 17, N. Y.

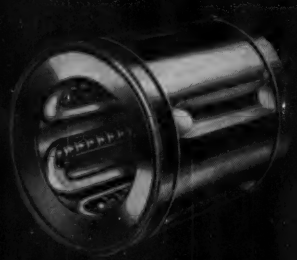
Circle 551 on Page 19→

NOW! *Adjustable Diameter and Open* THOMSON

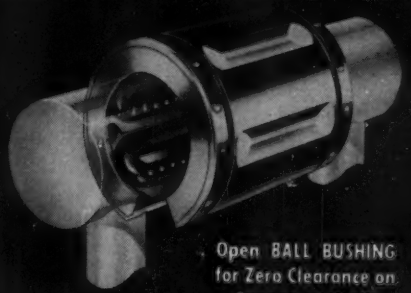
BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your LINEAR MOTIONS



Precision Series "A" and Low Cost Series "B" BALL BUSHING



Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Air Cylinders

for pressures to 125 psig

Midget air cylinders, designed to supply maximum power in minimum space, are double-acting units with 1-in. bores suitable for air pressures to 125 psig. Six models in the series provide stroke sizes of 1, 2, 3, 6, 9, or 12 in. Cylinders can be neck, angle-leg, or clevis-bolt mounted. Length of cylinders ranges from 4 19/32 to 15 19/32 in.,

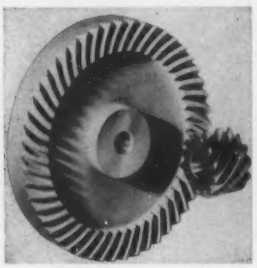
including 1-in. threaded section of piston rod projecting from cylinder. Cartridge-type bronze bearings and piston-rod seals can be replaced without dismantling the cylinders. Cylinders can be adapted to perform any push, pull, or reciprocating motion on parts of power presses, press brakes, clutches, and all types of doors, hatches, clamps, and materials-handling equipment. They can be actuated by hand, foot, pilot, cam, roller trip, or solenoid devices. **Scovill Mfg. Co. Inc., A. Schrader's Son Div.**, 470 Vanderbilt Ave., Brooklyn, N. Y.

Circle 748 on Page 19

Face Gears

are highly insensitive to mounting errors

Skew-axis Helicon gears are applicable through a ratio range from 3:1 to 400:1. Low in cost, they maintain a high degree of insensitivity



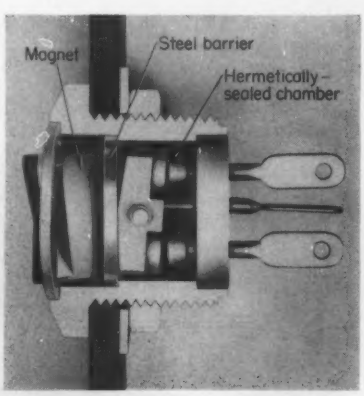
to mounting errors. Depending on size and application, gears can be hobbed, cast of metal or plastic, or compacted of sintered metal. Pinions can be rolled, milled, chased, or, on higher numbers of teeth, hobbed. **Spiroid Div., Illinois Tool Works,** 2501 N. Keeler Ave., Chicago 39, Ill.

Circle 749 on Page 19

Electrical Switch

miniature unit is actuated magnetically

FluxLink microminiature switch is a hermetically sealed unit actuated by a permanent-magnet circuit. It withstands extremes of cold, heat, shock, vibration, pressure, vacuum, and thermal shock, and has only one moving part. Force inherent in a magnet is piped through a solid metal barrier into a sealed chamber containing make-and-break electrical contacts. Force is converted into a "snap action," opening and closing the contacts. Springs are completely eliminated. Three switches operate through temperature range of −65 to +900 F, in or out of water. All units are ⅝ in. long by ¾ in. OD, and have voltage current capacities from 0-15 amp, 125 v ac. Adaptors and actuators of the three units are interchangeable. **Space Components Inc.,** 1048 Potomac St. NW, Washington, D. C.

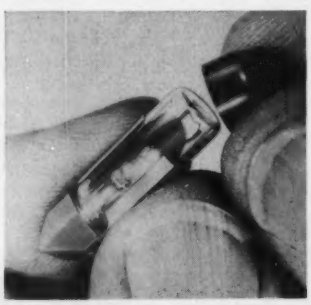


Circle 750 on Page 19

Electronic Indicator Lamp

has rated life of 3000 to 5000 hr

Low-cost electronic indicator-lamp combination includes a redesigned



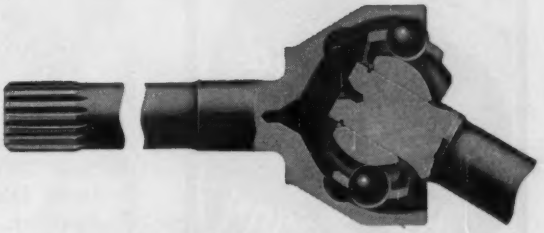
short-base indicator lamp, plastic color lamp-caps, multisocket strips for panel mounting, and single sockets. Lamp has rated life of 3000 to 5000 laboratory test hours. Flat-top end construction permits relocation of filament, greatly increasing end foot candles to provide up to 60 per cent more light. Particularly applicable as indicator lamps for computers, wide range of voltages and low-current drain make them suitable for data-processing equipment in both military and civilian applications. They also can be used in photocell activation, scanning devices, as lighted pushbuttons, in panel switches, and

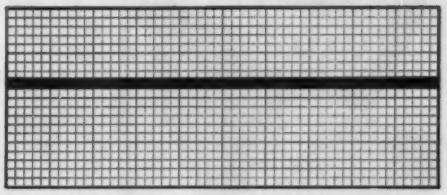
RZEPPA Universal Joints Transmit Torque Smoothly—*Even At High Angles!*

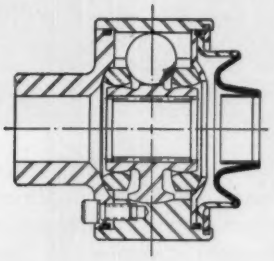
Rzeppa universal joints transmit 100% precision-smooth torque continuously—at angles of 35° and higher! Constant velocity action completely eliminates chatter, roughness and vibration. Size for size, you get longer shaft and bearing life, higher torque capacity with Rzeppa joints than with any other type!

The secret of Rzeppa's uniform power flow is that the driving balls are always in the bisecting plane of the driving and driven shafts. No matter what the shaft angle, torque flows evenly at constant velocity.

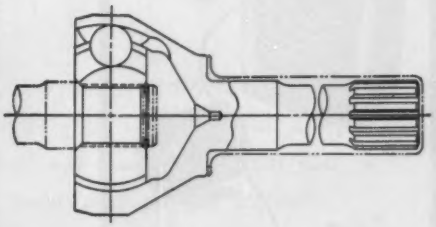
Rzeppa constant velocity joints are available in a wide variety of sizes, styles, angles and speeds. Rzeppa joints have been used successfully in equipment ranging from giant road-building and mining equipment to the most intricate aircraft and missile applications.



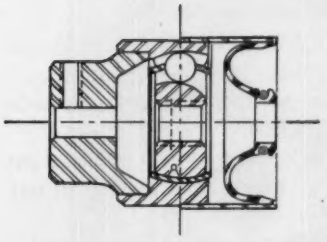




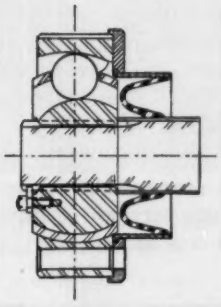
"MX" Type CV Joint (⅞" to 3½" swing diameter) . . . designed primarily for high speeds, low angles . . . blowers • compressors • servo motors • pumps • control devices • frequency converters • missiles • aircraft • dynamotors



Bell-Type CV Joint (15/16" to 2½" axle shaft diameters) . . . designed for high-angle driving steering axles used in road building machinery • mining machinery • industrial • automotive applications



"OV" Type CV Joint (2⅛" maximum swing diameter) . . . designed for smaller applications . . . ordnance • machine tools • servo mechanism • farm equipment • automotive equipment



Disc-Type CV Joint (from 2⅛" to 16¼" swing diameter) . . . designed for all types of industrial drive applications where constant velocity and trouble-free service are required.

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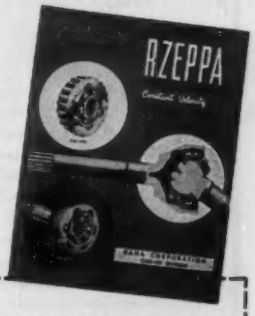

Please send my copy of Con-Vel's NEW engineering data folder on CV universal joints.

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CON-VEL DIVISION

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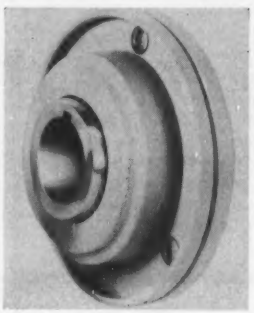
in aircraft instrumentation. Color caps are furnished in red, green, yellow, or white molded nylon and can be snapped over lamp or cemented to it for permanent installation. Lamps are available in standard 4, 5, 10, 12, 16, 24, and 28-v sizes. Standard current ratings are 35 to 45 ma. End foot candles of illumination range from 200 for the 4-v lamp to 1285 for the 28-v unit. **Sylvania Lighting Products Div., Sylvania Electric Products Inc.**, 730 Third Ave., New York 17, N. Y.

Circle 751 on Page 19

Flexible Motor Couplings

now for use with $2\frac{1}{2}$-in. bore size



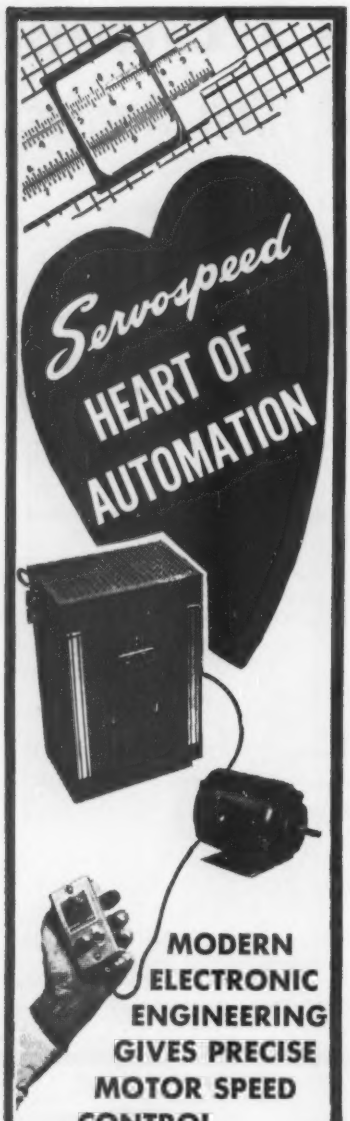
Three new features have been added to MC geared flexible motor couplings. Corrosive-duty cover of polypropylene has exceptional resistance to acids, alkalines, and solvents, and extends application of couplings to installations subjected to chemical attack. Larger size permits use of couplings in applications with $2\frac{1}{2}$-in. bore size. New spacer adapter serves as a demountable, rigid extension of motor shaft. **Link-Belt Co., Dept PR,** Prudential Plaza, Chicago 1, Ill.

Circle 752 on Page 19

Quarter-Turn Fastener

provides shock resistance

Vibration-mount fastener consists of standard No. 2 quarter-turn stud and retainer, with spring installed in a special mounting assembly. Unit is designed for use where shock resistance is important. Mounting assembly is composed of an aluminum plate to which an 0.5-in. thick neoprene-rubber boss is permanently bonded. Steel spring for closure is



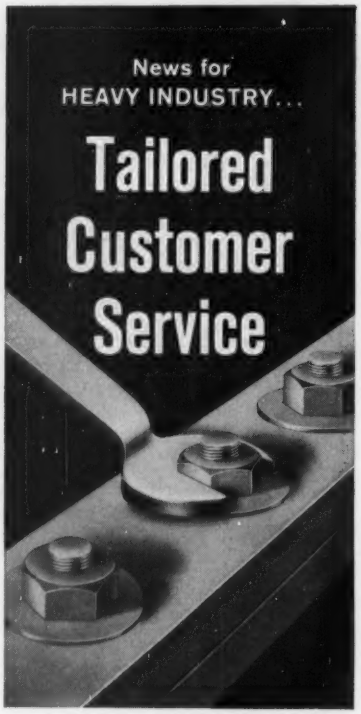
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 553 on Page 19



Whether you're building heavy machinery, steel mills, railroad cars, construction equipment or other capital equipment . . . we can save you time, money and production problems with *tailored customer service:*

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Circle 554 on Page 19

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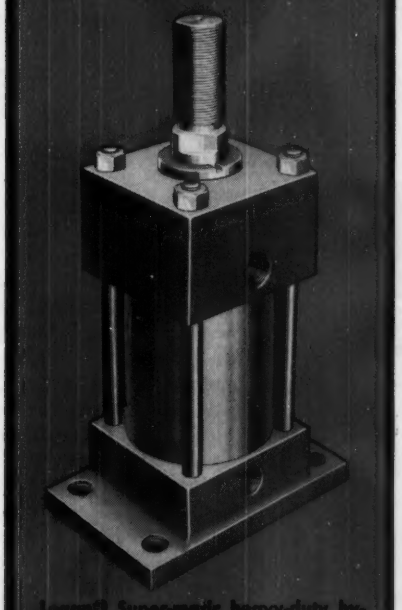
Hydraulic Cylinders

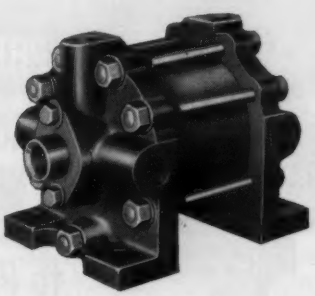
Logan® Rotocast Hydraulic cylinders. Operating pressures to 1500 psi.



Logan® Super-matic heavy-duty hydraulic cylinders. Operating pressures to 2000 psi.

Any size, any pressure, any stroke, any mounting to meet your specific need. Our engineering staff will be glad to assist you in helping to meet your design problems.

Logan 750 series rotating and nonrotating hydraulic cylinders. Operating pressures to 750 psi.



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Circle 555 on Page 19

The Design Equation that Saves You Money...

Use easy-to-install, economical National Retaining Rings to locate and position bearings or parts on pins, shafts and in housings. Eliminate grinding or machining shaft stock to form shoulders. You save time and material and reduce weight and space requirements. Ask for data on your specific application, today!

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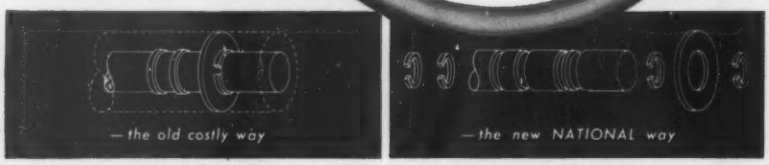
= improved design + economy!



ALL TYPES AND FINISHES AVAILABLE—National rings are supplied in square, round and rectangular types of carbon spring steel, bronze, beryllium-copper, stainless steel and aluminum in a wide selection of finishes. Send drawings or sample part for recommendations.

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Circle 556 on Page 19

Hobbs DUAL CIRCUIT PRESSURE SWITCHES

Add a NEW DIMENSION to Pressure Activation!

DOUBLE DUTY! Disconnects one electrical circuit while placing the other in operation. Industry-approved for a wide range of applications in dual circuit activation of various types of instruments, warning signals, safety devices, fuel pumps — in many other ways for making and breaking circuits. Ideal for locking out a starting motor while the engine is running. Can be used with oil or air . . . or with standpipe, almost any liquid or gas.

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- Phosphor-bronze diaphragm
- Alloy contacts • Preset at factory

Available in pound setting specifications in both circuits within ranges of 3-6, 7-14 and 15-60 psi. Compact — only 1-11/16" diameter. Pressure assembled and pre-tested at 150 psi. Designed for use on direct current.

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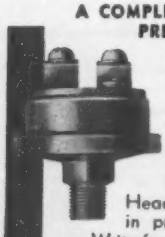

Also available — a wide selection of single circuit pressure switches. Built by the manufacturers of Hobbs Running Time Meters and Shock-Mounted Head Lights. Distributors in principal cities . . . Write for CATALOG PS605

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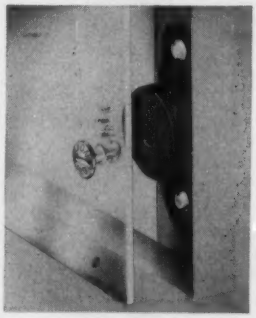
Circle 557 on Page 19



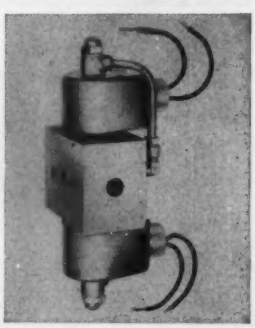
bonded into rubber boss to provide a sturdy, rattleproof unit capable of withstanding severe tension and shear forces. Two holes in the mount are provided for installation. Fasteners are available with studs in different sizes to meet varying thickness requirements. Each stud size handles a particular minimum-to-maximum range of thicknesses. **Southco Div., South Chester Corp.,** Lester, Pa.

Circle 753 on Page 19

Solenoid Valves

have only two moving pilot cores

Three-position, four-way dual solenoid valves are instantaneous in operation. Only two moving pilot cores and four flexing diaphragms are utilized. Supplied with rugged brass bar-stock bodies and poppet-type seats, valves are available with 1/4 or 3/8-in. pipe connections. In the closed-center position, when both solenoids are de-energized, flow is blocked to all orifices. Valves lock cylinder piston at any point of the stroke. During cycling, graduated or full-cylinder displacement can be controlled by energizing one of the solenoids. Dead-tight seating on air and liquids provides precision positioning of cylinders without creeping or drifting



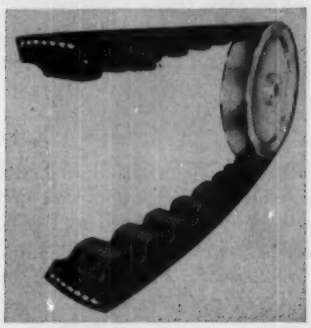
problems. Valves handle air, water, and oil from 10 to 250 psi on ac or dc voltages. Automatic Switch Co., Florham Park, N. J.

Circle 754 on Page 19

Notched V-Belt

has quiet, vibrationless running characteristics

Fully molded, fully jacketed, notched V-belt is designated CX. Primary advantages are quiet, vibrationless running characteristics, ruggedness, and high flexibility. Hence, belt runs smoothly over



small pulleys. Construction eliminates flex-cracking, and increases fatigue resistance. Firm, fabric-covered body resists cross-sectional distortion, maintains lateral stability, and resists changes in effective length. Manhattan Rubber Div., Raybestos-Manhattan Inc., Passaic, N. J.

Circle 755 on Page 19

Epoxy Plastics

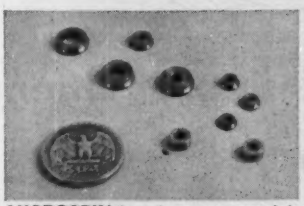
can be cured at low temperatures

Oxiron epoxy resins differ from conventional epoxy plastics in their molecular construction. They are well suited for insulation, lamination, molding, adhesives, and coatings. Resins react readily with anhydrides and combine excellent electrical properties with stability at high temperatures. They can be cured at relatively low temperatures, providing processing advantages and reducing chance of thermal damage to electronic components. Resins exhibit low shrinkage, low exotherm, and good adhesion on cure. Laminates with excellent strength-to-weight ratio can be prepared under low pressure in rela-

Stop Overdesigning—

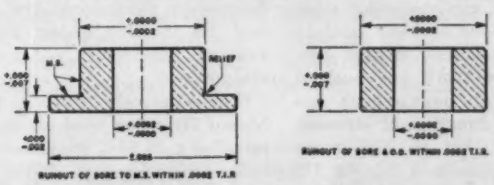
MAKE THE SHOE

FIT THE FOOT!



MICROSPIN—Northfield's new miniature precision instrument bearings. Designed for a wide variety of applications where speed and torque requirements do not justify the high cost of expensive ball bearings, but where precision instrument standards of tolerances, life, and friction must be maintained.

MICROSPIN bearings are precision-made of sintered bronze per MIL-B-5687, Type I, Comp. A, with 4% Molybdenum Disulphide. Oil-impregnated, completely self-lubricating. **Interchangeable with standard miniature ball bearings —at only ⅓ the cost! In stock—immediate delivery of production quantities!**



WRITE, PHONE for catalog-engineering data on standard and special sizes. Northfield Precision Instrument Corp., Island Park, L. I., N. Y. GEneral 1-1112

NORTHFIELD
PRECISION INSTRUMENT CORPORATION

Circle 558 on Page 19

new Mac-it IB Socket Head Cap Screw

provides a 26.53% improvement in working efficiency!

(Even over the new 1960 Series)

The taper tells the story. It's the taper of the new Mac-it IB socket head cap screw that adds 16.66% *more bearing surface* without an increase in head size. And there's 14.28% *less resultant compression* because of the change in direction of stresses.

It takes 12% to 23% more torque to release a Mac-it IB screw. That means it holds tighter. Indenting and corner fatigue are eliminated. And the new IB is self-aligning, tight-sealing, stronger, yet more streamlined.

Conservatively rated, the Mac-it IB socket head cap screw provides a 26.53% improvement in working efficiency.

YOUR MAC-IT DISTRIBUTOR will be glad to give you the facts on the new IB's right now; or *write for new, illustrated specifications bulletin.*

Mac-It Parts Co., Dept. 21, Lancaster, Pa.

MAC-IT ALLOY STEEL SCREWS

Circle 559 on Page 19

tively short cure cycles. Another significant characteristic is excellent adhesion to surfaces. **Epoxy Dept., Chemicals & Plastics Div., Food Machinery & Chemical Corp.,** 161 E. 42nd St., New York 17, N. Y.

Circle 756 on Page 19

Silver-Cadmium Battery

for portable television use

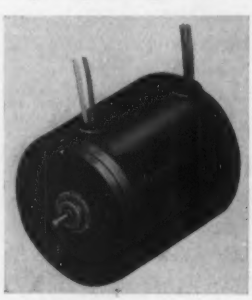
Small, light, silver-cadmium battery is capable of more than 2000 hr of operation. The eight-cell power pack, 8xYS5, weighs only 2.6 lb, is 3.16 in. wide, 3.24 in. long, and 3.92 in. high. It offers 22.4 w-hr per lb and 1.5 w-hr per cu in. Rated at 5 amp-hr, it has a nominal operating voltage of 8.7 volts. Battery can be operated at temperatures from −20 to +140 F. **Yardney Electric Corp.,** 40-50 Leonard St., New York, N. Y.

Circle 757 on Page 19

Synchronous Motor

subminiature unit has jewel bearings

New synchronous motor, SM-1, is 1 in. in diam x 1 12/64 in. long and weighs only 1.7 oz. Unit features jewel bearings, smaller and lighter than ball bearings, which afford less friction loss, even at temperature extremes, for minimum inertia and maximum accuracy and reliability. Operating at 115 v with



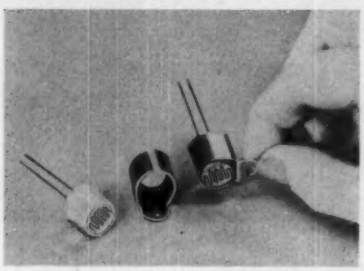
maximum power input of 2½ w, motor has a speed of 3000 rpm and power factor of 0.9. Rotation is reversible. Motor meets military requirements for temperature, altitude, vibration, and shock as prescribed by MIL-E-5272B. **Waltham Precision Instrument Co.**, 221 Crescent St., Waltham 54, Mass.

Circle 758 on Page 19

Photoconductive Cells

have high dissipation ratings

Rated at 250 v dc or peak ac, ½-in. diam power cells of the photoconductive type combine high dissipation ratings with a small, hermetically sealed package. Type 504 is an extremely sensitive cadmium-selenide unit with a relatively high speed of response. Type 505 is cadmium sulphide. Average continuous power rating for the cells is 0.5 and 0.25 w, with and without bracket mounted on heat sink, respectively. Peak spectral responses



for the 505 and 504 respectively are 5500 and 6900. Nominal resistances of the 504 and 505, at a color temperature of 2870, and 2 ft-c, are 1500 and 9000 ohms, respectively. **Clairex Corp.**, 19 W. 26th St., New York, N. Y.

Circle 759 on Page 19

Pushbutton Switch

has recessed nut to prevent accidental actuation

No. 9231 pushbutton starter switch incorporates a recessed, knurled face nut to prevent button from being actuated accidentally. Unit accomodates 6, 12, and 24-v systems, has silver inlaid contacts and contactors, and is weatherproof. Button and face nut are chrome-plated, and unit has two screw terminals. Switch is compact, over-all dimensions being 2-in. long x 1⅛-in. wide.

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66av.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

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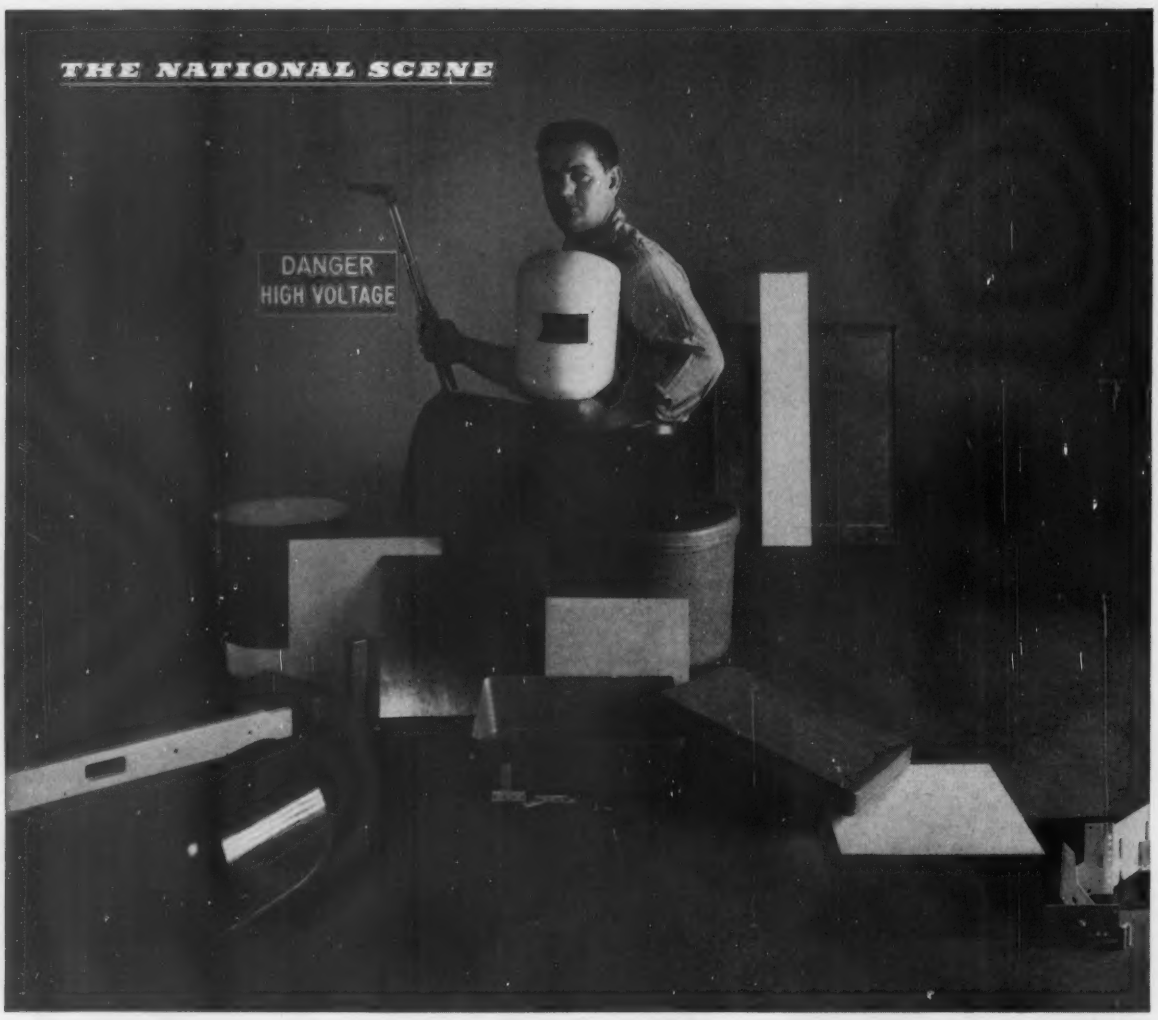
Circle 560 on Page 19



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Get an unbiased answer from National because we work either way

Giving the designer facts to help make the *right* design decision faster is perhaps our best "product." Offering the broadest line of plastic materials and services permits us to give impartial help. Take polyester glass mat.

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If the same facts point to a *machined* part, we'll work the same way . . . and with the same results. In this case National can furnish four standard grades from which to select the one best material. GP-9100-A is our general purpose, medium cost sheet with good electrical and mechanical properties. GP-9104 is also general purpose, but lower cost. GP-9202 is our flame resistant grade and best electrical grade except for arc resistance. GP-9204 is both flame *and* arc resistant, UL-approved for sole support of current carrying parts at temperatures up to 150°C.

One more point. The problems inherent in machining polyester glass laminates have had a tendency to discourage some designers from considering it. We suggest that you bounce this headache out of your production facilities and into ours.

You see, we are interested in *both* your design and machining problems. Your component will be skillfully machined at one of our four complete, "service-located" fabricating facilities.

Send for our Polyester Technical Bulletin 1164. We'll be happy to include, also, data on the full line of National materials—over 100 grades. Write to National Vulcanized Fibre Co., Dept. G-4, Wilmington 99, Delaware.

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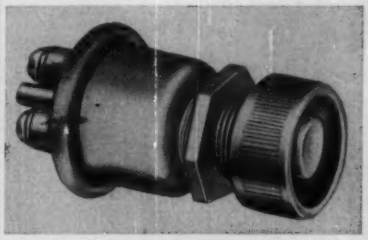
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario



Weight is only 0.18 lb. Cole-Hersee Co., 20 Old Colony Ave., South Boston 27, Mass.

Circle 760 on Page 19

Nameplates

of metal, foil, and decal types

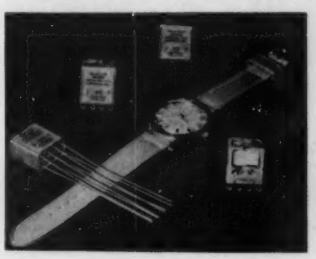
Line of nameplates for manufactured products of all kinds includes heavy-gage metals, self-adhesive foils, and decals, available in any size, shape, metal, or color. They can be chemically etched, lithographed, silk screened, or anodized. Plates are coated with a scratch and weather-resistant finish assuring long life and readability. Ward's Name Plates, 8502 Lyndon Ave., Detroit 38, Mich.

Circle 761 on Page 19

Microminiature Relays

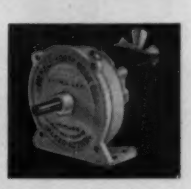
are 0.857 in. high and 0.800 in. wide, maximum

Type 30 microminiature relays are suitable for computer systems, missile or aircraft controls, communications equipment, and general electronic circuitry. They are furnished in 13 standard styles and 12 standard coils. Over-all height is 0.857 in. maximum, width is 0.800 in., and thickness does not exceed 0.387 in. Relays are hermetically sealed, back-filled with dry nitrogen, and can be supplied with helium tracer. Armature contacts are gold plated, and are rated to a maximum of 3 amp, 26.5 v dc. Minimum number of operations at 2 amp is 500,-



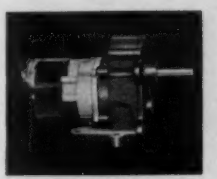
MERKLE-KORFF MK GEARED MOTORS

GEARED MOTORS



ALL KINDS OF MOTORS

Shaded pole induction, synchronous, reversible induction, series universal, series reversible, or D.C. shunt-wound motors.

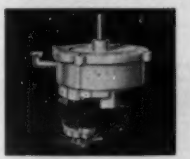


TORQUE FROM 300 TO .4 IN. LBS.

Merkle-Korff motors have high starting torques equal to or exceeding full load torques. No stalling, since M-K motors can start any application they can drive.

SPEEDS FROM 800 TO 1 RPM OR LESS

With Merkle-Korff motors you have a complete choice of shaft speeds. You get "Custom" motors designed to *your* specifications at mass production prices.



MOUNTS TO FIT ANY NEED

Here again Merkle-Korff provides what you need for a custom installation with ready engineered mounting facilities. Standard base, no base, ceiling mounted, right or left hand side wall mounting, vertical shafts—up or down. Right angle drives, multiple output shaft and electromechanical brakes are available to meet your special requirements.

MERKLE-KORFF GIVES YOU THE POWER YOU WANT. Merkle-Korff provides a wide range of speeds and torques in the F. H. P. field. These motors are husky, compact, long lived, and cost less per pound and for the torque delivered.

Merkle-Korff motors have these design features:

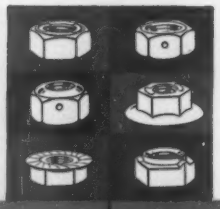
1. Maximum starting torques to start machines from any point in the duty cycle.
2. M-K motors are smaller in size and occupy approximately one-half the space required by other designs of equal output.
3. Precision, heat treated, hobbed gears sealed-in-oil. Dirt can't get in, oil can't get out.

Investigate now. Our application engineers will help you find the answer to your F. H. P. drive problems—without charge.

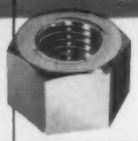
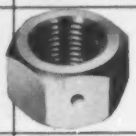
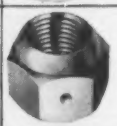
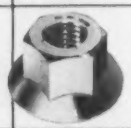
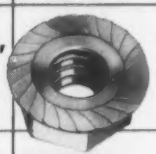
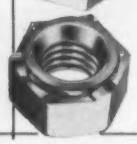
MERKLE-KORFF MK GEARED MOTORS

MERKLE-KORFF GEAR COMPANY
Dept. No. 215
213 N. Morgan Street
Chicago 7, Illinois
PHONE: MOnroe 6-1900

Circle 562 on Page 19

One  of these
CAN IMPROVE YOUR PRODUCT...

SIX GREAT
MACLEAN-FOGG
LOCK NUTS

MF **UNI-TORQUE**		A free starter with lock at the top. Withstands severe vibrations. Cuts assembly time.
MF **TWO-WAY**		The Lock's in the center of nut. Can be applied from either end. Permits bolt end to be flush with, or below, top of nut.
MF OPEN END **CAP NUT**		Has two-way center-of-nut lock. Used on furniture, appliances, toys, lawn mowers, tools, etc.
MF UNI-TORQUE **FLANGE NUT**		Combination lock nut and washer. Use on oversized holes; where extra bearing surface is needed.
MF **"WHIZ-LOCK"** FLANGE NUT		This one spins on. Serrations take a firm grip on work. Break loose torque higher than seated torque.
MF PILOT TYPE **WELD NUT**		You can have it with or without lock. Simplifies assemblies by means of self-locating pilot.

CIRCLE NUMBER FOR ILLUSTRATED CATALOG

SEE OUR CATALOG IN SWEET'S

MAC LEAN-FOGG MF LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

1925 35 1960 ANNIVERSARY

Circle 563 on Page 19

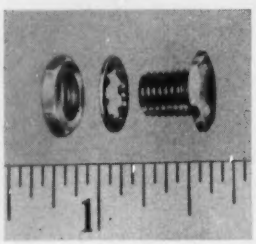
000, with 100,000 operations at 3 amp. Five standard mountings are available, with several socket styles. **Phillips Control Corp.**, 59 W. Washington St., Joliet, Ill.

Circle 762 on Page 19

Panel Bushing Assembly

three-piece unit accommodates 1/8 in. diam

No. 1818 panel bushing assembly consists of hex-ended bushing, standard hex nut, and internal tooth lock washer. Bushing is available in lengths of 3/8, 1/2, and 5/8 in. with 1/4-28 UNF thread. Concentricity



of bushing sleeve is excellent. Hex of bushing and hex nut are 3/8 in. double-chamfered. Bushing and hex nut are brass, and lock-washer is phosphor bronze. Finish of bushing, hex nut, and lock washer is 0.0003-in. bright nickel plate. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass.

Circle 763 on Page 19

Miniature Cartridge Heaters

operate at maximum surface temperatures to 1250 F

Featuring 1/8-in. diam in any desired length, miniature cartridge heaters are designed for applications where space is limited and heat requirements are high. The stainless-steel units operate at maximum surface temperatures to 1250 F. Heaters are for use in process machinery and equipment as well as aircraft, instrumentation, and specialized missile requirements. They can also be used as high-temperature resistors, supplying up to 50 w per sq in. maximum density for electrical and electronic applications. Heating wire is situated close to outside surface for maximum heat transfer and minimum internal temperature. Most voltages, including

. . . CONTINUOUS PROCESSING -- 1965 . . .

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

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Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

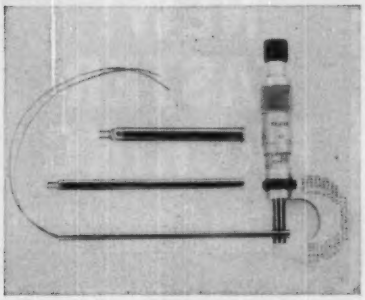
If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN



115 and 230, are available at no extra charge. Heating elements are supported on high-quality ceramic and are solidly packed with magnesium oxide and Teflon insulated. **Hotwatt Inc.**, 75 Maple St., Danvers, Mass.

Circle 764 on Page 19

Viton O-Rings

are standard in all ARP sizes

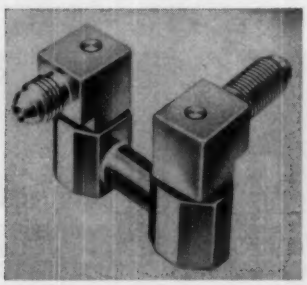
Viton O-rings are available as standards in all ARP (AN and MS) sizes. Sizes offered cover all compounds of the high-temperature material. New program makes possible finer dimensional control and better O-ring qualities. **Parker Seal Co.**, Dept. V-1, 10567 Jefferson Blvd., Culver City, Calif.

Circle 765 on Page 19

Swivel Connectors

for pneumatic or fluid applications

Line of ball-bearing swivel connectors is available for aircraft, missile, and industrial pneumatic or fluid applications. Connectors provide low rotating torque values under full operating pressure. Lightweight and available in most materials, they are furnished in single or multiple swivels. Twin-mounted unit, shown, is compact, made of stainless steel,



COST-CUTTING PRODUCTION TEAM!

. . . the two-way answer to assembly problems

Assembly problems are a designer's problems, too. Here's a combination that cuts production costs and gets rid of assembly problems in a hurry—Milford Tubular Rivets made to high quality standards to assure a better finished product for you . . . Milford automatic rivet-setting machines that can be quickly adapted to your particular fastening needs.

Milford's MANUAL OF MODERN RIVETING PRACTICE may have the answers to your riveting problems. Ask a Milford Representative to show you how to use this manual to cut production costs.

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • NORWALK, CALIFORNIA
ELYRIA, OHIO • AURORA, ILLINOIS • HATBORO, PA

Circle 566 on Page 19

ACCURATE AUTOMATIC FEEDING

from ounces to tons per hour

ERIEZ

HI-VI

VIBRATORY FEEDERS

Only feeders with totally enclosed drive element as standard construction. A-C operated, electro-permanent magnetic drive

Continuous, uniform flow of feed of all sizes and shapes of bulk materials for blending, mixing, sorting, cooling, etc. Variable feed rate. Completely automatic, extremely accurate. Increases production, provides quality control, reduces maintenance and operating costs.

Fully enclosed drive element (standard—no extra cost) makes units dust and moisture resistant; ideal for sanitary applications. Break-resistant glass fiber springs • New patented magnetic drive provides greater feeding capacity than comparable size units • No rectifier needed • Simple installation • Factory pre-tested • Fully proved in plants everywhere

NOW AVAILABLE! . . . economical, specially constructed units for hazardous dusty locations . . . fully acceptable by Mill Mutual.

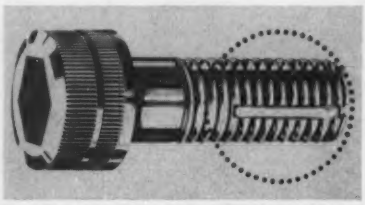
WRITE FOR FREE COMPREHENSIVE LITERATURE
Eriez Mfg. Co., 131-DB Magnet Drive, Erie, Pa.

ERIEZ

Circle 567 on Page 19

Socket Screws

have self-locking insert



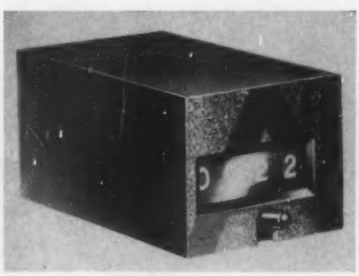
Socket screws with plastic Long-Lok inserts include cap screws, set screws, flat heads, button heads, shoulder screws, or pipe plugs. Polycap nylon insert performs over a wide range of temperatures, withstands impact, shock, and rugged environmental conditions. In industrial use, screws with inserts achieve superior thread engagement, high torsional resistance, and a self-locking drag. Insert does not protrude, passing through all normal clearance holes. **Parker-Kalon Div., General American Tranportation Co.**, Clifton, N. J.

Circle 767 on Page 19

Miniature Magnetic Counter

has single-stroke reset

Miniature magnetic counter is available as an additive, four-digit-type, single-stroke reset unit which records pulses with no loss of count up to 1800 counts per min. Actuated electromagnetically, counter weighs only 3½ oz and measures 15/16 x 1¼ x 2 in. in Cycolac case. Case is designed to facilitate nesting or stacking. Counters are available for all voltages for 6, 12, 24,



and weighs 9 oz. It operates from 0 to 3000 psi, with proof pressure at 4500 psi and burst pressure at 7500 psi. Temperature range is from −65 to +275 F. **Airaterra**, 620 Paula Ave., Glendale 1, Calif.

Circle 766 on Page 19

NEW! FASTER RACKING

for conveying all Sizes and Shapes of Stampings, Parts, etc.

ERIEZ

permanent non-electric

ERIUM-POWERED*

MAGNA-RAX

GET INCREASED CONVEYING EFFICIENCY. Magna-Rax magnetic power holds parts firmly in place while being conveyed . . . loading and unloading is faster . . . easier! One model will handle hundreds of sizes and shapes of parts . . . Magna-Rax are ideal for assembly line operations, where parts are conveyed from one point to another. Magnetic strength firmly holds parts while many operations such as tack off, dipping, spray painting, coating, degreasing, washing, inspecting, etc., are being performed . . . no need for special holes, lips, etc., on the parts as a means of holding.

Ideal for overhead or monorail systems. Rust and corrosion resistant . . . unaffected by temperatures up to 750°. Available in most any size and shape and with any number of Holding Magnets.

**Erium — an exclusive, high quality permanent magnetic power source specifically designed and energized by Eriez.*

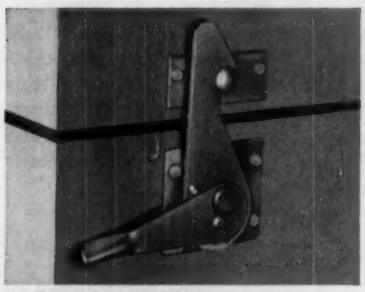
Write for data on this exciting new product.
Eriez Mfg. Co., 131-DA Magnet Drive, Erie, Pa.

ERIEZ

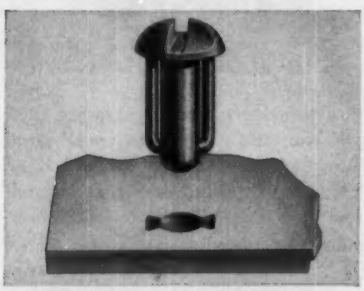
Circle 568 on Page 19

ANSWERS to specific fastening problems ...by SIMMONS

Economy, design flexibility, quick and easy installation, strength, and smooth, dependable action are advantages of these Simmons Fasteners, made for a variety of special applications. Whatever your fastening problem, engineering aid is available from Simmons.

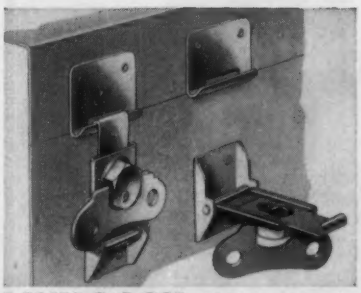


HOOK-LOCK–Springless, positive-locking latch which lies flat against mounting surface, open or closed. Provides high closing pressure and load-carrying capacity. For military as well as commercial container applications.

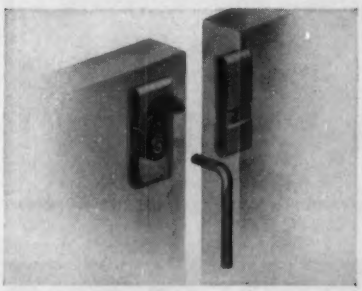


SPRING-LOCK–Perfect, proved blind rivet for removable covers and panels on electric and electronic equipment, sheet-metal automobile parts, appliances.

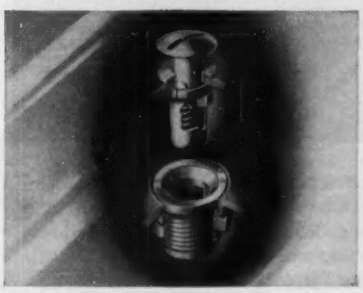
Plastic Spring-Lock Shelf Supports with "heart of steel" help refrigerator makers cut costs, speed production, simplify servicing.



LINK-LOCK–Ideal latching device where heavy locking pressure is necessary. Available in heavy, medium, light duty, for use in military and commercial containers and demountable construction.

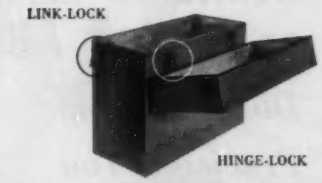


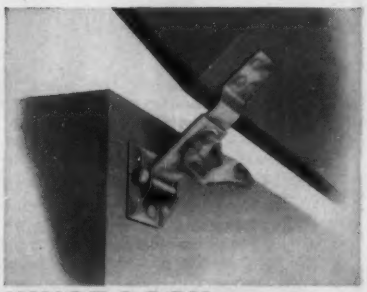
DUAL-LOCK–Impact and vibration-proof high-load butt-joint fastener that will not accidentally unlock or loosen. Recess in panels or surface mount. Withstands 7000-lb. tension.



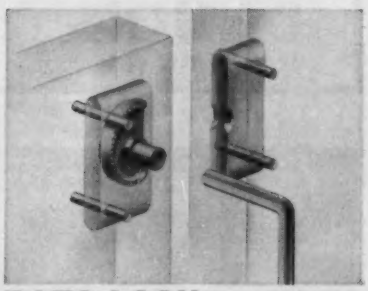
QUICK-LOCK–For assembling removable panels and access doors. Locked by a 90° turn. Various sizes and types, for weather-tight electrical units, cowlings, access panels.

SEND TODAY for your copy of the Simmons catalog, with specifications, applications, installation instructions for all Simmons Fasteners. Samples are available. For special assistance, describe your requirements.

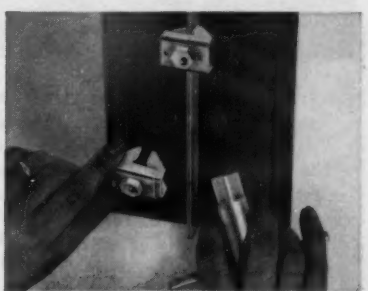




HINGE-LOCK–A rugged pressure hinge which provides a strong seal along the hinge line of gasketed equipment containers and transit cases. Matched hardware with LINK-LOCK.



ROTO-LOCK–Versatile fastener for butt or right-angle joints in portable shelters, partitions, knock-down shipping boxes, etc. Solidly built, springless.



CLAMP-LOCK–A simple and strong, positive-locking clamp for fast assembly (and disassembly) of permanent or temporary rooms and buildings of flanged-panel construction.

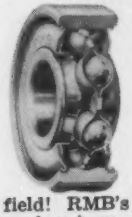
SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

See our condensed catalog in Sweet's Product Design File

RMB Filmoseal Bearings available in low-cost ABEC-1 as well as ABEC-5 tolerances.

Don't Pay for Precision You Don't Need



Big news in the miniature bearing field! RMB's famous Filmoseal Bearings—the only sealed miniature bearings—are now made to low-cost ABEC-1 as well as ABEC-5 tolerances. This means designers can use these advanced design bearings even in those slightly less demanding applications where cost is a primary consideration. Designers can take advantage of such features as:

1. Stainless-steel construction *throughout.*
2. Lubricant retention at *high temperatures.*
3. Non-contaminating *at all times.*
4. Two-piece ball separators for *high speeds.*

Open radial Conrad-type bearings are also available in this new grade. A wide range of sizes is available from 3/16" (0.1875") to ½" (.5000") OD including many metric sizes.

Write for your copy of the new RMB Miniature Bearings Catalog which gives full details on these as well as the entire line of quality RMB Bearings. Ask for Bulletin 62.

LANDIS & GYR, INC.

45 West 45th Street • New York 36, N. Y.

Circle 570 on Page 19

MACHINERY'S HANDBOOK

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Circle 571 on Page 19

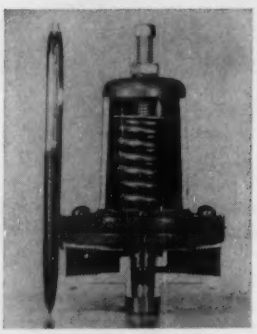
and 110 v dc. They withstand extreme vibration, shock, and temperature. **Abrams Instrument Corp.**, 606 E. Shiawassee St., Lansing, Mich.

Circle 768 on Page 19

Instrument Regulator

provides controlled supply of air or gas pressure

No. 080 instrument regulator has a wide range of applications in commercial, industrial, and utility operations. Providing a controlled supply of air or gas pressure, it is suited for supply lines for production-line equipment such as punch presses, pneumatic tools, and paint



sprays. Constructed of pressure die-cast aluminum, unit has maximum inlet pressure of 250 psi and outlet pressure ranges of 0-5, 5-35, and 35-100 psi. Optional construction includes handwheel adjustment and ¼-in. side outlet tap for pressure-gage mounting. **Meter and Valve Div., Rockwell Mfg. Co.**, 400 N. Lexington Ave., Pittsburgh 8, Pa.

Circle 769 on Page 19

Elapsed-Time Indicator

miniature unit has ⅛-in. characters

High readability and accuracy, through the use of a decimal-type counter with large characters for readout purposes, is provided by Model 1440 elapsed-time indicator. Unit presents only three digits at a time on a single reading line. Each of the white numerals is ⅛-in. high, prominently displayed on a dull-black counter drum. Indicator provides readings from 000 to 999 hr with return to 000, in 1-hr increments. Indicator has 0.670-in.

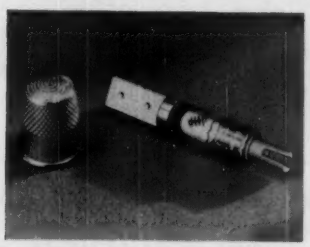
diam and length of 1⅞ in.; it weighs approximately 1.8 oz. Nominal input requirement is 115 v at 400 cps, single phase. Current is approximately 10 ma. Unit is completely self-contained, including the motor. **Bowmar Instrument Corp.**, 8000 Bluffton Rd., Fort Wayne, Ind.

Circle 770 on Page 19

Liquid Spring

has built-in dashpot

Miniature Model 38.008 Liquid Spring Shok provides a time-delay relay on an electronic circuit. Body of spring is only 1-in. long by ⅜-in. diam, including mounting ends. Unit provides fast compression spring action with a time-delay extension from built-in dashpot. Time delay at end of ¼-in. stroke can be adjusted to provide up to 42 min delay for travel of 1/16-in. return stroke, then release for rapid travel



the last 3/16 in. of the stroke to actuate other circuitry. Spring force is 8 lb end-load and 6 lb preload. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y.

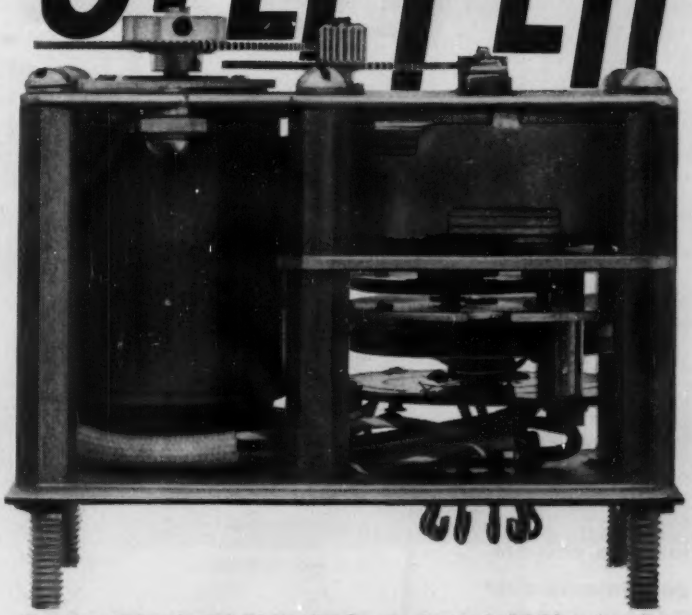
Circle 771 on Page 19

Pillow Blocks

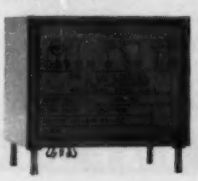
provide high efficiency and durability

Suitable for normal-duty applications, three series of strap-type pillow blocks have simplified, two-bolt mounting arrangement which auto-

FANCY STEPPER



Stepping devices from A. W. Haydon Co. can do wonderful things to pulses ...with pulses...and for pulses. For instance, one precision gated stepping switch acts as a pulse divider for a random or variable pulse source—or as a frequency divider if the pulse source is constant. Another works in conjunction with pulses, supplying single or multiple switch closures with an accuracy virtually equal to that of the pulse source itself. Still a third will count a predetermined number of pulses, rotate a stepper switch, return the counter to 000, and cut off the pulse source. ■ The remote positioning device illustrated is but one of A. W. Haydon Company's fancy steppers. Here a precision gated stepper switch has been coupled to a synchro transformer. Similarly, precise angular positioning of rotary components such as potentiometers, dials and indicators can be controlled. Based only on the number of pulses received (not incremental changes in voltage or phase angle), it will hold a set position whether power is on or off, and will home the synchro to the zero reference on demand—ready to accept another setting. ■ All A. W. Haydon Co. stepper motors are all-electric—no ratchets, linkage, contacts or other mechanical crutches are used. Their power consumption is low, accuracy is extremely high. ■ Send for technical brochure SP9-1 and find out more about pulse driven steppers and their application.

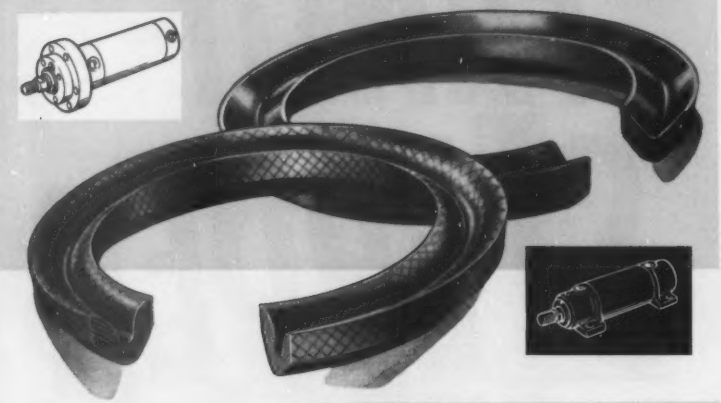


THE AWH HAYDON COMPANY

249 North Elm Street, Waterbury 20, Connecticut

Circle 572 on Page 19

DESIGN ESSENTIALS FOR BETTER HYDRAULIC PACKINGS



THESE BASIC FEATURES are part of every "John Crane" Hydraulic Packing. They assure packings that meet the most rigid requirements of hydraulic service ...a good initial seal, long life, efficient performance over wide pressure ranges and stability in the fluid medium.

1. Pressure access allows immediate pressure distribution and packing response.

2. Ball joint nesting surfaces facilitate breathing without pinching, wedging or lip collapse.

3. Adequate lubrication reservoir.

4. Uniform bottom thickness eliminates weak points and insures centerline hinge action.

5. Molded-in lip interference insures tight static seal and conformation to bore and rod deflections.

6. Heel clearance prevents "riding" at heel and eliminates lip toe-in.

7. The fabric in the "V" rings is so laid to assure maximum strength—an important consideration for maximum packing life.

Tell us about your standard requirements and ask for recommendations and/or assistance in the creation of a combination of packings that will best handle individual operating conditions. Request Bulletin P-333 for general information.

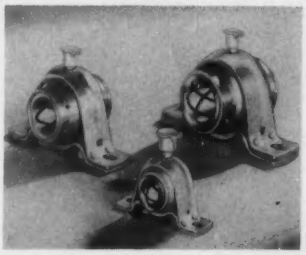
Crane Packing Company, 6425 Oakton Street, Morton Grove, Ill. (Chicago Suburb).

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

John Crane

MECHANICAL PACKINGS · SHAFT SEALS · TEFLON PRODUCTS · LAPPING MACHINES · THREAD COMPOUNDS

CRANE PACKING COMPANY



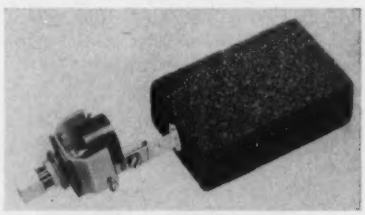
matically draws cap into proper adjustment against base. Lightweight due to simplified housing design, units deliver high efficiency and durability. Deep Well ball assembly is self-lubricating and self-aligning. **Randall Graphite Bearings Inc.**, Greenlawn Avenue and Lake Street, Lima, Ohio.

Circle 772 on Page 19

Adjustable Valve

float-type unit has no moving parts

Adjustable float valve operates on a single-pivot principle for trouble-free use. Called the A-1106-9, valve has no moving parts. All-rubber valve seat is adjustable and can be reversed. Design of valve seat enables it to act as a splash shield, and permits easy replacement. Chrome-plated valve jet assures



positive shut-off. Applications include evaporative coolers, ice-making machines, and other automatic-control applications. **Skuttle Mfg. Co.**, Milford, Mich.

Circle 773 on Page 19

Brass Adapter

provides leakproof seal between plastic tubing and metal fitting

Brass adapter, available for various sizes of tubing, provides a positive, leakproof seal between plastic tubing and a standard compression-type metal fitting. Regular compression nut is inserted on plastic tubing. Adapter then is inserted in end

NEW "TORTURE CHAMBER" FOR RADIAL BEARINGS

duplicates Navy acceptance tests

This is a torture chamber for radial bearings. Here BCA ball bearings are run . . . hour after hour . . . under loads of 5000 pounds per bearing—matching U. S. Navy acceptance tests for radial bearings. This special BCA-built device is an important control and development tool. It provides essential data for BCA's ball bearing research program.

This tough performance test is an example of the greatly expanded research and testing facilities which BCA has developed for the benefit of bearings users. Reason: to provide the finest possible ball bearings to customers. Results: bearings which consistently exceed performance specifications on whatever kind of jobs they are designed for.

Among the extensive new facilities at the BCA laboratories is a Temperature-Humidity-Controlled Instrumentation Room containing precision instruments, many of which have been specially designed and modified for bearing research. There are a number of unusual testing devices, too; in design, identical to equipment in customers' plants. On these, BCA bearings can be tested *under the exact operating conditions specified by the customer.*

BCA provides a complete line of ball bearing sizes and types for nearly every kind of industry. They're standard original equipment on automotive, machine tool, earth moving, and agricultural equipment, for example. And, you'll find BCA a dependable source not only for high-performance ball bearings but engineering assistance, should you need it. For more information, contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

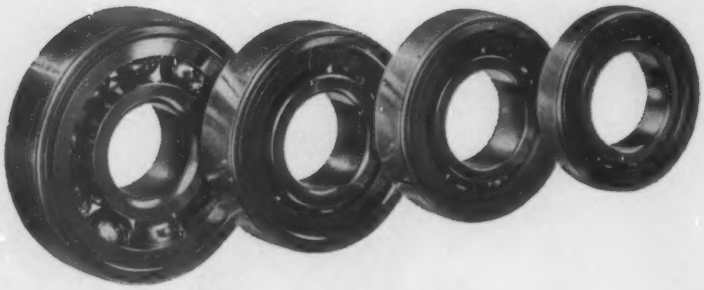
BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

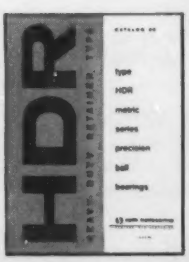
Circle 574 on Page 19

NEW HEAVY DUTY (HDR) PRECISION BALL BEARINGS

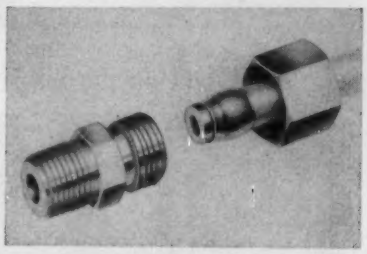


A significant step forward in bearing technology. These precision bearings combine the advantages of a maximum ball complement with deep groove ball races uninterrupted by filling notches or counterbore. The result is a new kind of ball bearing with superior performance characteristics. Up to 56 percent more capacity than conventional Conrad type ball bearings; or, in terms of life, up to 280 percent more. Also greater rigidity, less deflection, and increased resistance to shock loads. Made in standard metric series and sizes, to ABEC-3 and ABEC-5 grades of precision.

Find out for yourself —
write today for catalog 60.



split ballbearing
A DIVISION OF MPB, INC.
308 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE



of tubing and connection is completed in the usual way. Seal is leakproof, even with finger closure, to pressures that burst plastic tubing. **Robert Mfg. Co.**, 9035 Venice Blvd., Los Angeles 34, Calif.

Circle 774 on Page 19

Pressure-Sensitive Material

provides excellent resistance to creep, water, heat, cold

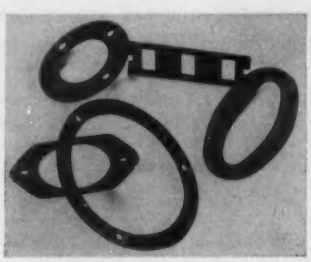
Particularly suited for general-purpose applications, including bonding fabric, paper, wood, plastic, glass, and metals, Rez-N-Glue 378 has a natural-rubber base. The clear, pressure-sensitive adhesive is supplied with heavy-syrup viscosity for fast-drying application with brush, roller, or Doctor Knife. It remains soft and can be used within a few minutes or covered with release paper for deferred use. One gallon prepares approximately 200 sq ft. **Schwartz Chemical Co. Inc.**, 50-01 Second St., Long Island City 1, N. Y.

Circle 775 on Page 19

Gasket Material

for extreme environments and operating conditions

Vistex III fiber-reinforced Teflon, nitrile-rubber gasket material has excellent stability to corrosive gases and liquids under both high and low temperature conditions. Properties include 100 per cent compression recovery, exceptional tensile strength, resistance to oil and aro-



Circle 575 on Page 19

matic fuels, good flexibility, and nonadhesive and noncorrosive properties. Material is available in sheet form, up to 30 x 60 in., and in standard 1/8, 1/16, 1/32, 3/32, and 1/64-in. thickness. It has 84 lb per cu ft density and minimum tensile strength of 1000 psi. Material is well suited for gaskets where light weight is a factor. It can be precision cut or punched into gaskets, strips, or washers. **American Felt Co.**, 2 Glenville Rd., Glenville, Conn.

Circle 776 on Page 19

Pushbutton Switch

is combined with panel light

Panel-mounted switch-light combination can be supplied DPDT, double-break, positive action, either with momentary contacts or push-on, push-off mechanism. By use of a special gold contact and increased

contact pressure, it is possible to make and break a current as low as 1/4 of 1 mil. Unit has snap-in feature for rebulbing from front of panel. Standard button is 3/4 in. square, but can also be supplied with other size lenses (square or round) in any color. **Switch Div., Pendar Inc.**, Dept. EE, 14744 Arminta St., Van Nuys, Calif.

Circle 777 on Page 19

Polyethylene Tubing

is strong, tough, and exceptionally flexible

Parker-Pol polyethylene tubing is available in four sizes: 1/4-in. OD x 0.040-in. wall thickness, 5/16 x 0.062, 3/8 x 0.062, and 1/2 x 0.062-in. Tubing is strong, easy to handle, and can be cut easily with a sharp knife or shears. Tubing is easy to

IF relays cause you as much trouble as they do us, you will undoubtedly welcome information on how to get rid of them. Probably the most fashionable way to do the switching is to use transistors, and as a public service Sigma hereby offers some application data toward this end. The Search for Truth must go on.

Right off the bat, it must be conceded that transistors have the edge in several important physical and dynamic respects. Relays are certainly bigger, heavier and slower, and their useful life is nowhere near infinite—primarily because they all have such old-fashioned things as moving parts. Nor are relays immune to unlimited shock and vibration (the best we've been able to do on a subminiature type, and keep it operating within spec, is 30 g's to 5000 cycles).

There are a few things relays *are* good for, however, even though "Relayized" may never sell a single product. For instance: signal circuits can be isolated from load circuits . . . signal and load can be AC or DC, in any combination . . . circuits with high voltage to ground present no particular problems, and relatively high voltage loads can be handled . . . inductive loads can be switched "off" when they're supposed to be off. On "sliding" or slowly varying signals, the right relay will also provide clean, positive switching and it won't fry if the circuit develops a mild defect. It is true, if not grammatical, to say that a relay is many orders more "off" and several orders more "on" than those other things.

The fact that relay contacts more closely approximate the ideal switch—no ohms one way and infinite ohms the other way—also means something when dry circuit switching is your problem. With loads in the order of 0.1 microwatt, a properly designed relay can provide dependable switching.

Further, if 3-position, polar, center-stable switching (Sigma "Form X") is needed, a single relay will do the job. And if the requirement calls for having the switch "remember" and stay in the last switched position, a polarized, magnetic latching relay (our "Form Z") will do just that without stand-by power.

There are also such considerations as *cost* (where the switching is of the pinball machine variety), *stability* as a function of temperature, and *amplification* (10,000:1 load to signal ratio), that lean in favor of relays. But the main ones are those mentioned earlier—which we're banking on to keep us from going bankrupt this year. In the meantime, we're looking around for diversification possibilities—something in a good solid state, perhaps.

*or, Ten Easy Steps to Utopia.

SIGMA INSTRUMENTS, INC.
89 Pearl St., So. Braintree 85, Mass.
An Affiliate of The Fisher-Pierce Co. (since 1939)

Circle 576 on Page 19

FEATURED IN CONTROL SYSTEMS OF MISSILE PROGRAM!

New FLOW CONTROL VALVES

pressure compensated

From **RIVETT**

Rivett Hydraulic Flow Control Valves are *now* being introduced to the trade after four years of thorough field testing in advanced applications for both government and industry. These valves may be used as ordinary "meter in," "meter out," or "bleed off" types of compensated flow control valves by keeping the bypass port plugged in the subplate, and piping the "inlet" and "outlet" ports as desired. This usage means excess oil is spilled over a relief valve so pump is always at full horsepower.

On some meter-in circuits, with the "bypass" port piped to tank, the "inlet" and "outlet" can be piped as above, but any excess oil fed to the valve will flow to tank. As long as the fluid motor or cylinder is working at less pressure than system relief valve setting, the Rivett 3-port flow control will maintain oil flow to the work as set, the bypass port will flow excess oil to tank at the work pressure, and therefore the pump is using horsepower only at the rate determined by work requirements.

FEATURES

1
Knife edge orifice positively assures consistently uniform low flow; and minimizes change of flow when change of fluid temperature occurs.

2
No drain connection required because special pressure balanced Teflon seals are used.

3
Maximum flow capacities up to 125 G.P.M. in 1½" size are standard.

4
Valves are usable as two port and three port models.

5
Vernier knob has provision for safety lock wiring.

6
Valves are available with return free-flow check.

RIVETT, INC.
Dept. MD-4, Brighton 35, Boston, Mass.
The Better You Know Hydraulics — The Better You Like

RIVETT

connect with brass or aluminum Intru-lok fittings. It is chemically resistant, nontoxic, and odorless and has superior cold weather and aging characteristics. **Parker Fittings & Hose Div., Parker - Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 778 on Page 19

Electrical Terminals

resist high vibration

Vibrakrimp solderless electrical terminals are for use where excessive vibration is encountered. Seamless, annealed, tin-plated brass sleeve permanently attached over regular terminal barrel provides high strength. Part of sleeve extends beyond barrel and is crimped in the same operation as the barrel to grip wire insulation permanently, preventing creep. Terminals are furnished in ring, hook, spade, flanged spade, and rectangular

tongue types in standard sizes. They feature ¼-in. minimum barrel length that eliminates squeeze-outs and shearing and allows wider crimp for extra-strong connections. **ETC Inc.**, 990 E. 67th St., Cleveland 3, Ohio.

Circle 779 on Page 19

Flexible Hose

with Teflon inner core transmits live steam

White Line hose for steam transmission incorporates pure bronze wire-reinforcing braid, swaged fittings, and extruded Teflon inner

TODAY AND TOMORROW

whatever may be your problems

BUNTING®

BEARINGS *Supply the answers*

Cast Bronze Alloys...Powdered Sintered Metals...Bearing Aluminum Alloys

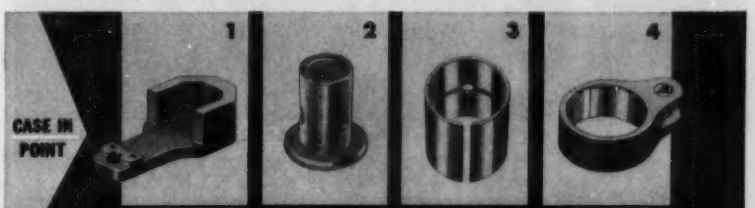
Why pay more for a bearing or part than you have to? Let Bunting help you get your requirements down on the lowest cost level compatible with adequate performance.

Today and tomorrow "the best" bearing means one that will do the job at the lowest possible cost. Let Bunting help you find the best bearing.

Bunting offers a highly competent designing, engineering and manufacturing facility operating in the field of bearings and special parts.

All modern proven materials are available, others are under study. Two plants with advanced equipment—of our own design—assure absolute production control and lowest manufacturing cost.

Let us re-examine your current bearing applications, or work with you on new requirements. Send in your prints for study and pricing. No cost or obligation.



1 The great and diverse cost advantages of powder metallurgy are revealed in the highly complex nature of this bearing support plate for power tools made in Bunting's Powdered Sintered Metals Plant.

2 An Aluminum Alloy helped cut the cost of this high speed turbo super charger bearing with its intricate machining of many dimensions and close tolerances.

3 Bunting exclusive methods and equipment reduced to the minimum the cost of this cast bronze spindle bearing with its extremely rigid specifications.

4 This connecting rod demands a fine profilometer reading on the finish of the bores in the two holes, axes of which must be parallel to each other within extremely close limits. Bunting makes such high precision work feasible cost-wise.

MACHINING SERVICE: **Emergency service machine shops in Bunting Branches are there to render immediate low cost service on bearings or parts needed for experiment or maintenance. Your local Bunting Distributor can arrange for such service.**

Write for these:

No. 1...ENGINEERING HANDBOOK OF POWDER METALLURGY—A comprehensive technical treatment of engineering and manufacturing of sintered metals, bearings and parts.

No. 46—TECHNOLOGY OF BUNTING BEARING ALUMINUM—A technical treatise on the composition and machining of Bearing Aluminum Bar Stock.

No. 158—GENERAL CATALOG—Complete listings of Cast Bronze and Sintered Bronze Stock Bearings and Bars and Bunting Bearing Aluminum Bars available from stocks of local distributors all over America.

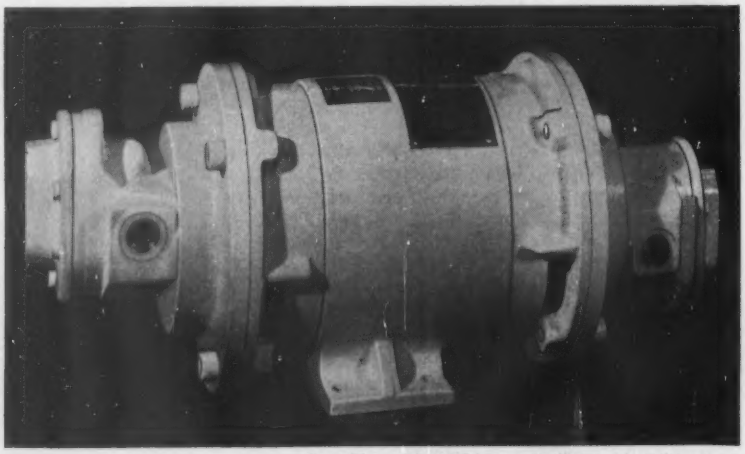
THE BUNTING Brass and Bronze Company · Toledo 1, Ohio · Phone EVergreen 2-3451

BEARINGS, BUSHINGS, BARS & SPECIAL PARTS OF CAST BRONZE, SINTERED METALS OR ALUMINUM ALLOYS

Circle 578 on Page 19

This tracking antenna is an important part of the Air Force Ballistic Missile Early Warning System. Goodyear Aircraft Corp. developed it for R.C.A., prime contractor on the system.

Why Goodyear Designers Choose Brown & Sharpe Pumps To Lubricate B.M.E.W.S. Antenna



One of four paired B&S pump units used in antenna.

Problem: Designers of this antenna needed 8 pumps, pre-mounted in pairs on opposite ends of 4 double-ended, "spec." motors. This would provide four compact units, to: (A) Replenish oil in the main drive system; control position of yoke on large, variable-displacement drive pump. (B) & (C) Supply lube oil for the whole antenna. (D) Lubricate a data gear box. The pumps must remain self-priming from minus 65°F to plus 160°F; must be rugged and long-wearing. (Antenna life requirement is 10 years.) Fast delivery from a single manufacturer was preferred.

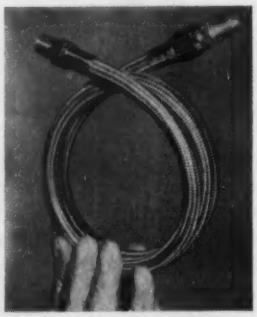
Solution: Brown & Sharpe pumps met all requirements. B&S high-pressure pumps (of a unique, long-wearing design,) are used for (A), (B) and (C). B&S rotary geared units, available quickly, are used for application (D).

Idea: For the best solution to any pump problem — write Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, Rhode Island — or contact your nearest B&S engineer-representative.

Be sure to see us at Booth 1131, ASTE Tool Show, Detroit, April 21-28

Brown & Sharpe
PRECISION CENTER

core, to provide reliability with resistance to deterioration, abrasion, scaling, blow-offs, and leakage. Inner core, completely resistant to most chemicals, will not embrittle, work-harden, or deform after millions of flexing cycles at 400 F. All-bronze wire braiding provides protection against rust, and is braided in a pattern that provides maximum flexibility with long fatigue life and burst strength. All-brass swaged fittings provide protection against leaks and blow-offs. Hose is available as assembled lengths or as



specialized lengths with separate fittings. Sizes range from 1/4 to 1 in. standard hose size. Burst pressures are approximately six times the maximum recommended operating pressure. **Titeflex Inc.**, Hendee Street, Springfield 4, Mass.

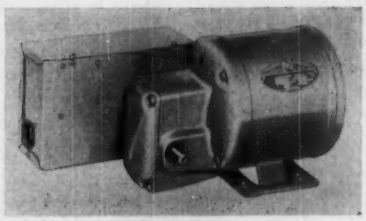
Circle 780 on Page 19

Electric Motors

are controlled by signal from limit switches

Gear-O-Matic electric motors are available in 1/6 through 1 hp. Motor control is accomplished by signal from manual or automatic limit switches, and connections are provided in control box for actuation by electronic signal equipment. Built-in safety reverse switch is actuated when powered equipment meets a predetermined resistant force. Motor, an instant-reversing type, applies full power in either direction in response to switch actuations. Limit switches are built in to stop motor when driven devices close, open, or should be stopped at a given point. Ratios of 20:1 through 30:1 are available with worm-gear reduction in motor end bell. Motors power doors, windows, ventilators, and remote valves,

Circle 579 on Page 19



and impart automatic control to indexing, conveying, tool operation, and other automation requirements. **Franklin Electric Co. Inc.**, Bluffton, Ind.

Circle 781 on Page 19

Perforated Plastic Sheet

for use in strainers, filters

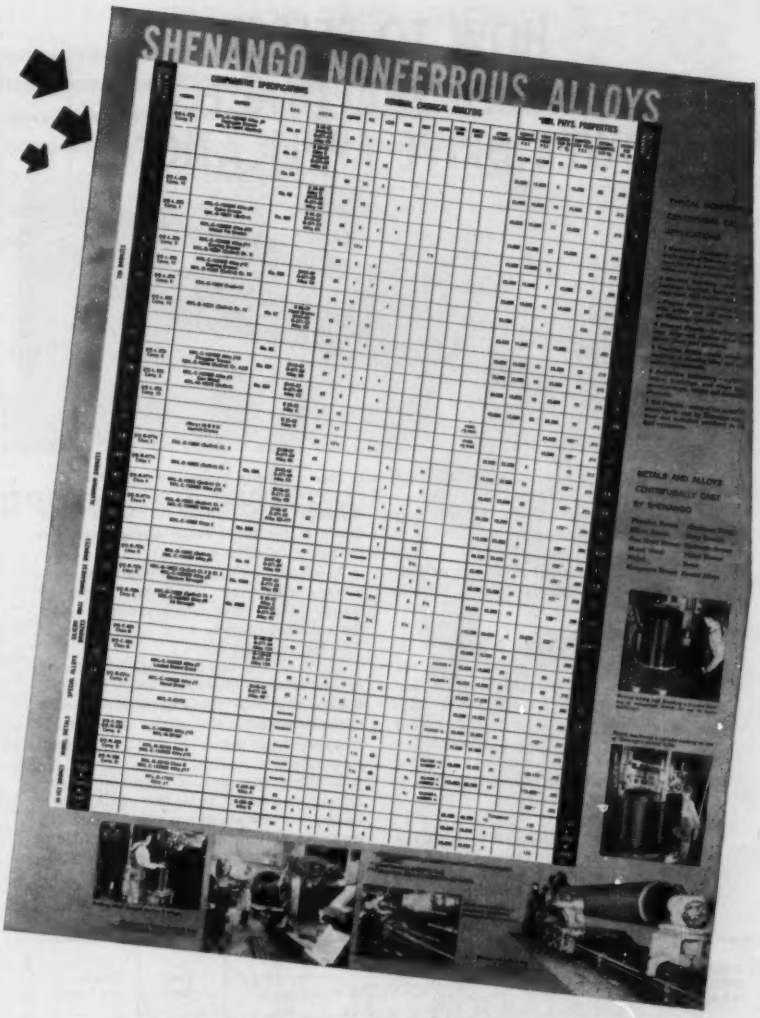
Filter-Mesh perforated sheet of PVC or polypropylene is an unplasticized material which offers highly chemical resistant strainer elements or filter cloth for use in conjunction with extremely corrosive acids, alkalis, solvents, and chemical salt solutions. PVC sheet is suited for contact with strong oxidizing chemicals at temperatures to 168 F, and polypropylene sheet offers good general chemical resistance with exceptional properties in solvent service and is suitable for temperatures to 250 F. Both types of sheet are available in 40, 34, 26, 18, 14, 10, 6, and 5-mesh perforated sizes and can be supplied in rolls to 100 ft long. Material offers excellent electrical and thermal insulation properties along with unusual physical stability and decorative appearance. **Dorak Products Corp.**, 78 Pearl St., New York 4, N. Y.

Circle 782 on Page 19

Filter Unit

can be removed and cleaned without contaminating lines

New filter-unit design allows for removal and cleaning of the element while keeping pipe lines uncontaminated. Simple clamp closure permits removal of body tube, and unit can be cleaned and reinstalled in minutes. Filter is furnished in several pipe sizes. It contains a porous-metal element which can be used with or without a filter aid. Elements are supplied as cylinders, bayonets, stars, or in special types. Materials available include stainless



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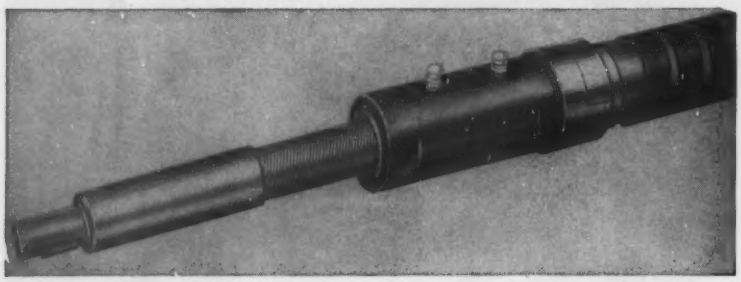
Circle 580 on Page 19

HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered.

1. Torque (lb. in.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM) — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example).

3. Operating Radius—in making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

Ratings — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)
2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.)
3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	.185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.503/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

EXAMPLE—How to use the table:

The problem is to transmit ½ H P at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque 1.5 x 18.5=27.75
3. Correction factor for unsupported shaft 27.75 x 1.6=44.4 lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core no. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divide by 1700. 54 × 1500 ÷ 1700 = 47.6 lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

STOW

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STOW MANUFACTURING COMPANY

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steel, Monel, nickel, and Inconel. Filter can be designed to withstand up to 10,000 psi; 125 or 300 psig is standard. Filtration is available to as low as 2 microns nominal. **Micro Metallic Div., Pall Corp.**, 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 783 on Page 19

Variable-Speed Pulleys

utilize small top-width belts and sheaves

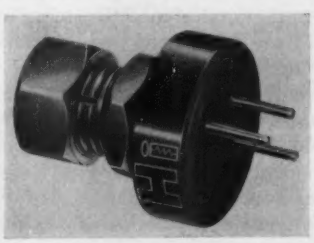
Series of low-cost variable-speed pulleys consists of six sizes ranging from fractional to 5 hp with speed ratios to 4:1. Utilizing smaller top-width belts and sheaves, pulleys provide instant speed changes while equipment is running. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill.

Circle 784 on Page 19

Trimming Potentiometer

for panel mounting weighs less than 6 grams

Subminiature, high-temperature potentiometer, Model Wee-50, has ½-in. diam, weighs less than 6 grams, and is for panel mounting. It operates in temperatures from −55 to +200 C. Unit withstands shock to 20 g, altitude 50,000 ft, and vibration from 30 g, 10 to 2000 cps. It meets MIL-E-5272A and other specifications. New winding technique ensures that every re-



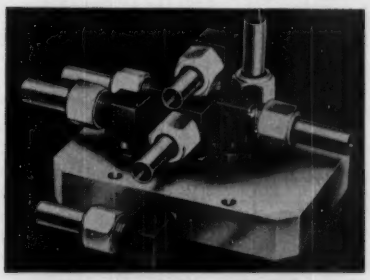
sistance turn is locked in position and bonded to the mandrel for greater wiper tension, lower noise, repeatability, and permanence of wiper position for a given adjustment of the lead screw. It also provides greater high-power ratings over wide temperature range. **Handley Inc.**, 12960 Panama St., Los Angeles 66, Calif.

Circle 785 on Page 19

Hydraulic Fitting

makes a positive metal-to-metal seal

Self-Seat hydraulic fitting is for use in hydraulic, pneumatic, lubrication, instrumentation, and other fluid systems. It makes a positive metal-to-metal seal and requires no swing clearance. Fitting has straight



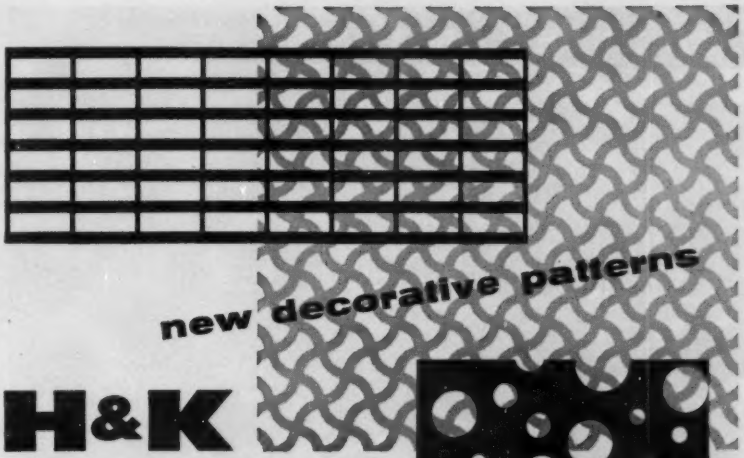
thread and consists of a stem and body with a floating nut. Tightening the nut forces the stem to coin its own seat. Since the body of the fitting does not turn when the nut is tightened, it can be used in confined spaces. Only 1-in. center-to-center space is needed for a ½-in. fitting. Main features of the fitting include installation without special tools and positive, leakproof seal without O-rings or special seat preparation. Fitting is available in sizes from ½ to 2 in. OD and in all conventional shapes. **Flodar Corp.**, 16911 St. Clair Ave., Cleveland 10, Ohio.

Circle 786 on Page 19

Plastic Cable Jackets

protect breakouts branchouts, and splices

Protechtor covers, available in a full range of sizes and a variety of colors, provide protective covering for breakouts, branchouts, and splices. Covers are furnished with two or more legs, and conventional T, Y,



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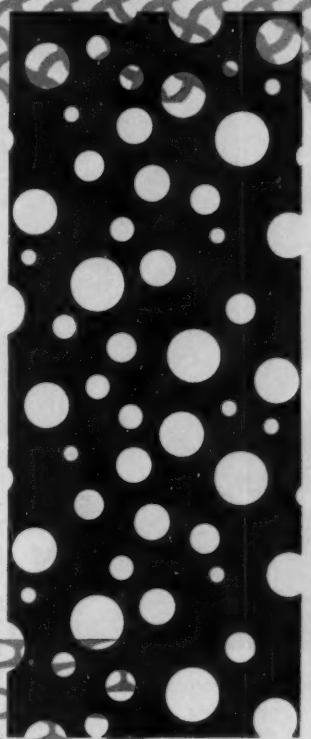

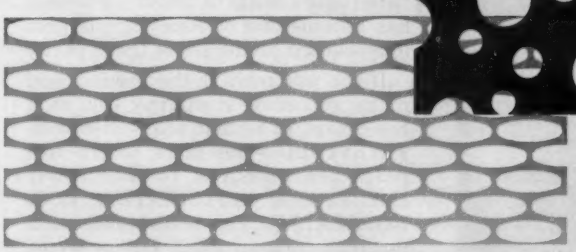

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Circle 582 on Page 19

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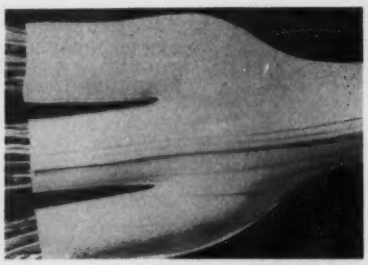


and fork designs are available for distribution cable branchouts. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles 14, Calif.

Circle 787 on Page 19

Flow-Control Valves

have consistently uniform low flow

Series 8600 line of 3000-psi, pressure-compensated, flow-control hydraulic valves are used as ordinary meter-in, meter-out, or bleed-off types. Use of the valves in a circuit allows excess oil to be spilled over a relief valve, thereby always permitting pump to operate at full horsepower. Knife-edge orifice assures consistently uniform low flow,

and minimizes change of flow when change of fluid temperature occurs. Use of special pressure balanced Teflon seals eliminates drain connection required. Maximum flow capacities to 125 gpm in 1½-in. size are standard. Four basic sizes are available, with choice determined by desired capacity. **Rivett Inc.**, Brighton 35, Boston, Mass.

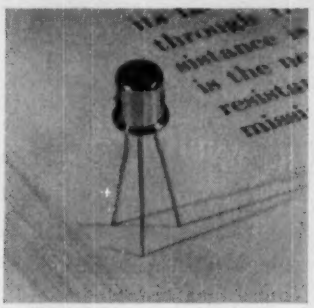
Circle 788 on Page 19

Tunnel Diodes

of gallium arsenide

Two models of gallium arsenide tunnel diodes with peak currents of 22 and 10 ma are available as research samples. Tunnel diode per-

forms switching and amplifying functions like the transistor. It is easier to make and has higher frequency capabilities. It is also smaller, more stable, and more resistant to nuclear radiation and temperature change. Tunnel diodes have applications in computers, earth satellites, missiles, and high-frequency communications equipment. Capacitance for both units is typically 1.5 picofarads per ma. Typical peak-to-valley current ratio of both devices is 15:1. Typical voltage swing of the diodes is 1.0 v, twice the voltage swing of germanium units. Typical peak-point



current variation is less than a total of 2 per cent over the temperature range from −55 to +150 C. Diodes are housed in TO-18 standard transistor package. **Semiconductor Products Dept., General Electric Co.,** Charles Building, Liverpool, N. Y.

Circle 789 on Page 19

Low-Alloy Steel

has high strength and moderate corrosion resistance

High Strength No. 5, low-alloy steel is available for applications which require high strength but only moderate corrosion resistance. Corrosion resistance is equivalent to that of copper-bearing mild steel. Fabrication in the as-rolled condition is limited to simple bending across the rolling direction and very light flanging and forming operations. Fusion welding can be done without preheating or post-heating. Material meets requirements of SAE Specification 950 and ASTM A-242-55. Metal is supplied in both hot-rolled strip and hot-rolled sheet (slit sheets or coils, also in plates). Thicknesses range from: 0.074 to 0.0971 in. inclusive, in 50-in. maximum width;

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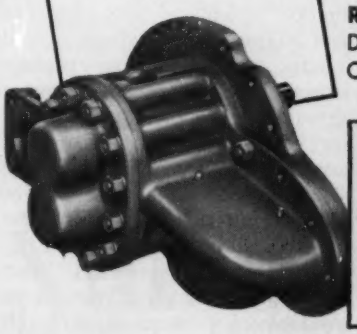

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Circle 585 on Page 19

0.0972 to 0.1270 in. inclusive, in 60-in. maximum width; 0.1271 to 0.375 in. inclusive, in 72-in. maximum width. **Armco Steel Corp.**, Middletown, Ohio.

Circle 790 on Page 19

Pilot Relief Valve

for hydraulic systems operating in remote places

Hydrelief pilot-operated relief valve, designated model VPR3P3F, is suitable for use in hydraulic systems that operate in remote places where there may be difficulties in trying to follow a frequent or regular maintenance routine. Capacity of the valve is 30 gpm when offset mounted and 20 gpm when mounted

in line. Pressure adjustment range is from 250 to 3000 psi. Pressure rise between cracking of the relief to full flow at the maximum rated capacity and pressure is only 6 per cent. **Parker Hydraulics Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 791 on Page 19

Hydraulic Pump Motor

has mounting bracket to eliminate mounting base

Type H-7 close-coupled hydraulic pump motor is a rugged, heavy-duty unit with corrosion-resistant, cast-iron frame. Use of mounting bracket eliminates mounting base and adaptors, and reduces over-all length of pump-motor package. Concentric mounting is assured through the use of normalized castings that prevent warping of precision machined parts. Rigid, precision splined coupling allows direct pump connection. Completely enclosed housing protects against hazard of exposed couplings. Both single and double-end models are available for standard hydraulic

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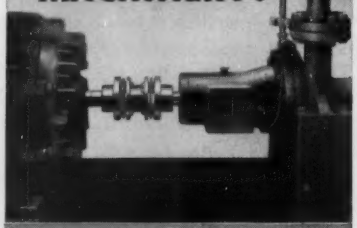

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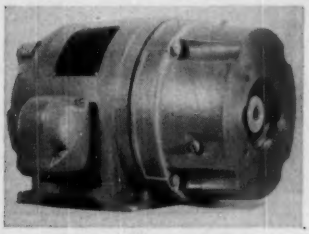


pumps. Ratings range from ¾ to 50 hp. U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 792 on Page 19

Insulating Material

consists of acrylic fiber and acrylic resin

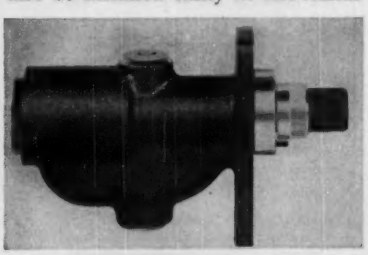
Duroid 2100 flexible electrical insulating material is primarily intended for hermetic applications where resistance to freon-oil mixtures is required. Material is composed of acrylic (Orlon) fiber in combination with acrylic resin. Material provides higher dielectric strength per unit of thickness than existing types of fibrous sheet insulating materials, and retains the mechanical strength of existing products. Material is available in 13-in. wide rolls, in thicknesses from 0.010 to 0.030 in. Rogers Corp., Rogers, Conn.

Circle 793 on Page 19

Flow Regulator

controls flow as low as 35 cc per min

New flow regulator is especially applicable to machine tools, air-oil cylinders, and other operations where extreme low rates of oil or fuel flow must be controlled accurately. Unit controls flow as low as 35 cc. It has high-strength, heat-treated, cast-aluminum body with hardened-steel internal parts. Designed for panel mounting, it can also be installed easily in test stands



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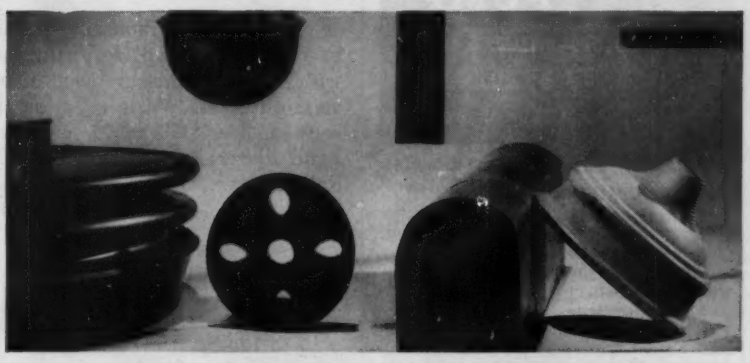

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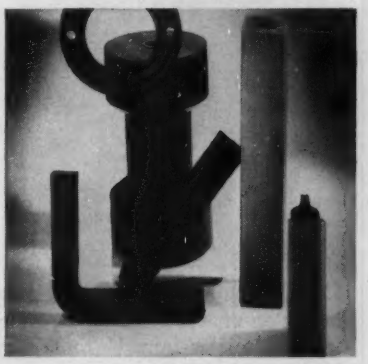

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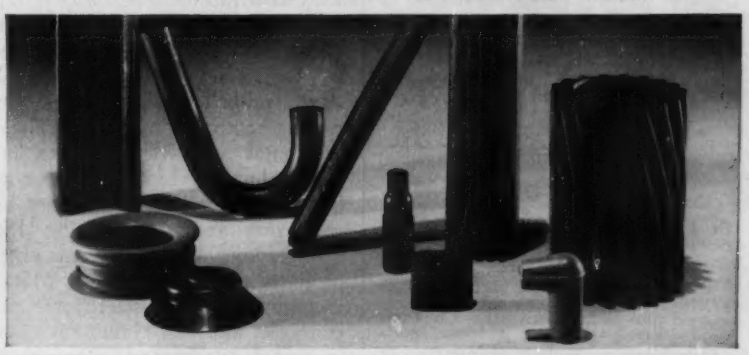

OIL AND GAS...SPECIFY **STALWART!**

Shown above are custom rubber parts that exemplify Stalwart's total production capabilities and design versatility. Produced to meet customer specifications, complex configurations are molded, extruded, cut, calendered and spliced from special compounds to provide the ultimate in part quality, performance reliability and production economy. And you get a big bonus in *service* with every order ...from the time you request a quotation ... through the design and compounding stages... right down to *prompt* delivery. Stalwart produces rubber parts from all types of natural and synthetic rubber, including new Viton. Check with Stalwart's Plastic Division for injection molded parts to meet those very requirements.

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THE WORLD'S LARGEST PRODUCER OF SILICONE CUSTOM RUBBER PARTS

STALWART RUBBER COMPANY

Send for your copy of the new Stalwart Catalog.

180 NORTHFIELD ROAD • BEDFORD, OHIO
PLANTS in BEDFORD, OHIO and JASPER, GEORGIA

Circle 587 on Page 19

"Integral pump" unit adapts to numerous configurations

Consisting of an inner and outer Gerotor and an eccentric-locator ring, the unit becomes a complete pump by simply boring the casting or frame of the mechanism to accommodate the locator ring O.D. and by providing porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft. Obviously, such a built-in pump costs far less than complete pumps purchased outside. This results from the elimination of mounting pads, couplings, lines, connections and accessory drives. *(Fig. 1.)*

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

The matched elements are thus as easily built in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi. *(Fig. 2.)*

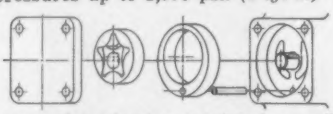


Fig. 2. Nichols integral pump-package is as easily installed as an anti-friction bearing.

A unique combination of adaptability and reliability also account for the growing popularity of integrally designed pumps built with these Nichols packaged components. A wide range of applications include circulating or lubricating systems, scavenging oil away from pumps, powering low-pressure hydraulic systems, replenishing other pumps, hydraulic brakes etc.

The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump — simple and compact in basic design, (has only two moving parts). It is lightweight, valveless, provides exceptional performance and has low wear over a long service life. It is balanced and extremely quiet in operation.

Investigate this cost saving development. Just send us information about the fluid you want to handle, rate of flow, pressure and dimensional limits. We'll provide specific recommendations, estimated costs and technical data.

W. H. NICHOLS CO.
Woerd Ave., Waltham 54, Mass.

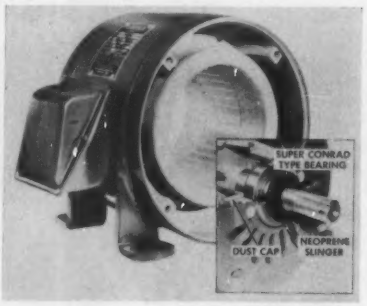
Circle 588 on Page 19

or can be bracket mounted. Built-in check valve provides free flow with minimum pressure drop in reverse direction. Valve is adjustable between 2 and 90 cu in. per min. **Fluid Power Accessories Inc.**, 2051 Railroad Ave., Glenview, Ill.

Circle 794 on Page 19

Induction Motors

line now includes ½ to 125-hp sizes



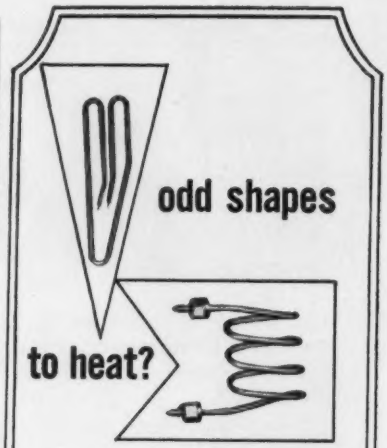
Line of three-phase, squirrel-cage induction motors has been expanded to include sizes from ½ to 125 hp. Multiguard thermosetting plastic is used to encapsulate and impregnate the stator. Die-cast aluminum rotor is supported by doubly shielded bearings. Bearing and fabricated-steel end-bell design permit operating motor with shaft in either horizontal or vertical position. Sealed housing having a reservoir for grease storage and facilities for regreasing increases bearing life. Positive housing seal prevents entry of destructive contaminants. Motor, including fabricated-steel frame and end bells and cast-aluminum rotor, is coated inside and out with a vinyl-based primer and an acid-resistant paint. **Lincoln Electric Co.**, 22801 St. Clair Ave., Cleveland 17, Ohio.

Circle 795 on Page 19

Air-Hydraulic Cylinders

in double-acting or spring-return types

Type AS air and hydraulic cylinders are available in bore sizes of 7/8, 1⅛, 1½, and 2 in. They are either double-acting or spring-return type, as well as double or single ended. Cylinders feature one-piece square heads, ground and polished stainless-steel rods, nylon bearings,



use

VULCAN TUBULAR HEATERS

Vulcan Tubular Heaters can be formed into an endless variety of unusual shapes to provide a lot of heat in a little space. They are easily cast into aluminum or other metals. They are ideal for immersion in liquids, soft metals or molten salts. Straight tubular heaters are readily clamped to metal surfaces or inserted in machined grooves. And they can be furnished with flattened surface for even more effective heat transfer.

Vulcan Tubular Heaters are available in a wide choice of lengths — 10″ to 185″ (special, shorter or longer); diameters — .250″; .280″; .333″; .450″; .496″; .540″; wattage — 10 to 10,000 (or higher); voltage — standard 120, 240 or 480; special 6 to 600 (or higher); sheaths — copper, steel, aluminum, high temperature alloys.

Write for catalog and prices.

VULCAN
Versatility in Electric Heating
VULCAN ELECTRIC COMPANY, Danvers, Mass.

Circle 589 on Page 19

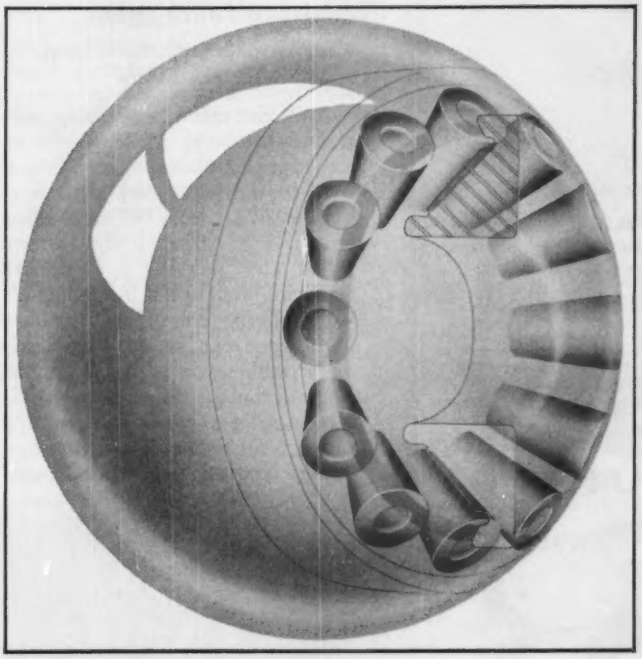
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

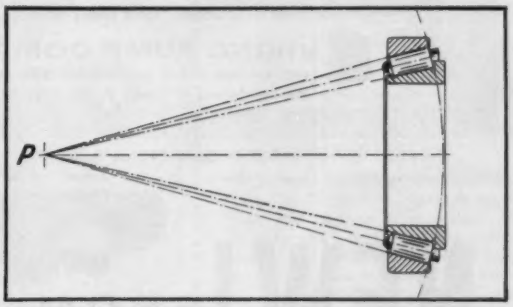
One in a series of technical reports by Bower

BEARING BRIEFINGS

SPHERICITY — ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.



True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. *It will always roll in this one path precisely, without sliding or skewing.* But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers *and* the raceway have a true spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would *touch all points on each roller's head!*

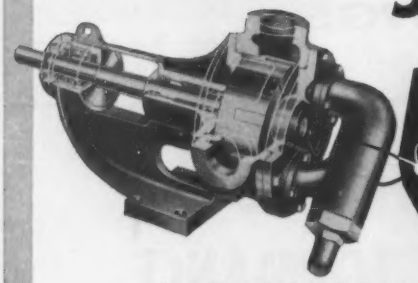
In effect, then, each roller's taper determines the radius of a hypothetical sphere whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 590 on Page 19

FASTER SPEED



NOW SAVES ON
VIKING
Stainless Steel and other Alloy Pumps

Now Viking Positive Displacement, Heavy-Duty type pumps, made of stainless steel, monel, mild steel and other alloys, can be operated up to 100% rated speed on thin liquids.

By increasing the capacity and speed of a pump, upwards of $300 to $400 can be saved on some sizes.

Entirely new, modern foundry facilities and manufacturing processes enable the complete line of Viking alloy Pumps to meet still more exacting requirements.

If your specifications call for alloy pumps, see how you, too, can save on our new line of full speed Viking alloy Pumps.

For information, send today for catalog MH

VIKING PUMP COMPANY
Cedar Falls, Iowa, U. S. A. In Canada, it's "ROTO-KING" pumps
See Our Catalog In Sweet's Product Design File

Circle 591 on Page 19

NEW! FROM UNITED

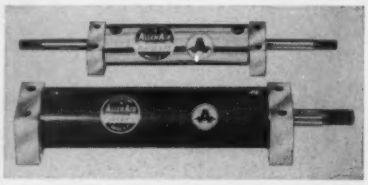
Metallic O-Ring Retainer Plates cut machining and assembly costs!

Now mating flanges can be sealed without machining grooves to hold metallic O-rings! United's metal retainer plates can be made for most junctures, regardless of the number of ports.

Openings in retainer plates function the same as groove walls. They furnish O-ring compression limit, control O-ring hoop tension, position O-rings for accurate matching of multiple hole patterns in mating flanges, and permit interchangeability of flanges. For price quotations, send flange drawing and specifications for fluids, pressures and temperatures to:

UNITED METALLIC "O" RINGS
manufactured by
United Aircraft Products, Inc.
Box 1035 • Dayton, Ohio

Circle 592 on Page 19



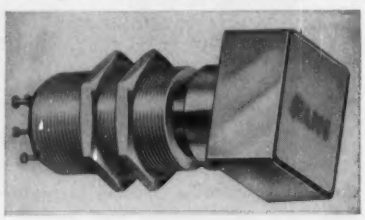
and honed brass or steel tubes. Cushions are optional, and a choice of packings is available. Units are stocked in strokes up to 20 in., but any stroke to 168 in. is available. **Allenair Corp.**, 255 E. 2nd St., Mineola, N. Y.

Circle 796 on Page 19

Miniature Switch-Light

incorporates replaceable lamp with large plastic lens

No. 6B Switchlite is available with ratings from 1½ to 48 v. It incorporates a replaceable, high-brightness, incandescent lamp with large plastic lens. DPDT snap-action switch with extremely high current rating and long life is used. All leads are brought out independently to turret-type terminals so that lamp and switch can be used separately or in combination with one another for their fullest utilization. For 25,000 operations, minimum, electrical rating is 28 v dc at 7 amp resistive, 4 amp, inductive (sea level), and



2.5 amp, inductive (50,000 feet). **Eldema Corp.**, 1805 Belcroft Ave., El Monte, Calif.

Circle 797 on Page 19

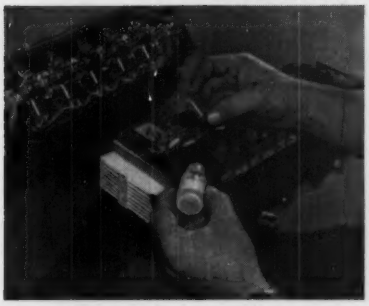
Limit Switches

for use in high-speed applications

Specifically designed for applications on high-speed, precision-production machines, new limit switches are oiltight. They are suited for installations where high impacts and adverse environmental conditions are major factors in limit switch failure. Each switch is sealed to

(Advertisement)

No. 12 of a series



Eastman 910 Adhesive solves another production bottleneck

Electronic Associates, Inc., of Long Branch, N. J., makes PACE analog computers for industrial and military use.

By using adhesive bonding in place of bracket-mounting, its design engineers achieve simpler, faster, space-saving emplacement of 10 electrical relays in each of the several digital attenuator units associated with the computer.

One drop of Eastman 910 Adhesive quickly bonds each aluminum relay case directly to a phenolic potentiometer cover plate, eliminating mounting brackets. Wiring is reduced, too.

Eastman 910 Adhesive was selected because it "was cleaner than other adhesives, resists vibration, does the job, and sets quickly."

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

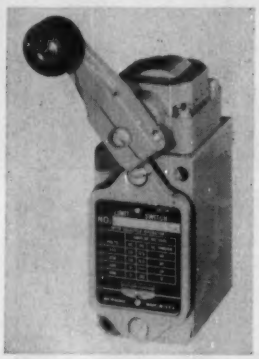
Eastman 910 Adhesive is used as it comes. No mixing, no heating. When spread into a thin film between two surfaces, light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9104 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-4, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

Circle 593 on Page 19

check seepage of oil, coolants, moisture, and abrasive grit. External seals are located at operating shaft bearing and between cover plate and contact assembly. Internal seal between operating head and switch base provides double insurance against entrance of liquids into contact cavity. Use of thermoplastic material provides enclosed positive contact visibility. Switches are available in both surface and flush-type mountings and are calibrated



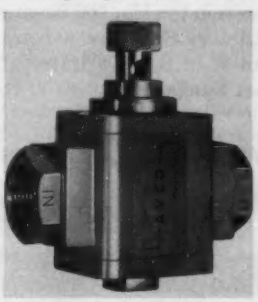
to control tolerances producing identical operation of all switches. Cutler-Hammer Inc., 328 N. 12th St., Milwaukee, Wis.

Circle 798 on Page 19

Safety Bleed Valve

for air or hydraulic supply-line use

Low cost, snap-action combination shut-off and bleed valve, Loc-Master, has a compact, aluminum-alloy body and a positive, instantaneous shut-off action. A quarter turn of thumb nut completely stops all line pressure and automatically bleeds off pressure on the downstream side. Closing the valve prevents accidental recharging of the supply line, and hole in the valve stem permits padlocking in closed position. Design permits unrestricted



The Wilkerson
SELF-DRAINING
FILTER

automatically protects air equipment

Harmful oil, water, and dirt as small as 5 microns are completely separated and pneumatically discharged from compressed air.

MINIMUM AIR LOSS

Dependable draining automatically. Large drain opening, Buna N valve seat and positive "snap-action" of float prevents costly air loss. Will flow up to 635 CFM with only 0.75 to 1.65 PSI pressure drop. Full sump can be expelled every 3 seconds—eliminates undependable human draining.

NEW ANTI-CORROSIVE COATING

All moving parts especially coated to prevent electrolysis and provide long life.

VERSATILE

Can be used as single unit or in combinations; transparent or metal bowl; from ¼" to 8" P.T.; for pressures 10 to 250 PSI.

WRITE TODAY

for complete information contained in new circular #1027

WILKERSON CORPORATION

Dedicated to keeping the NEW in pNEUmatics

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Englewood, Colorado

Circle 594 on Page 19

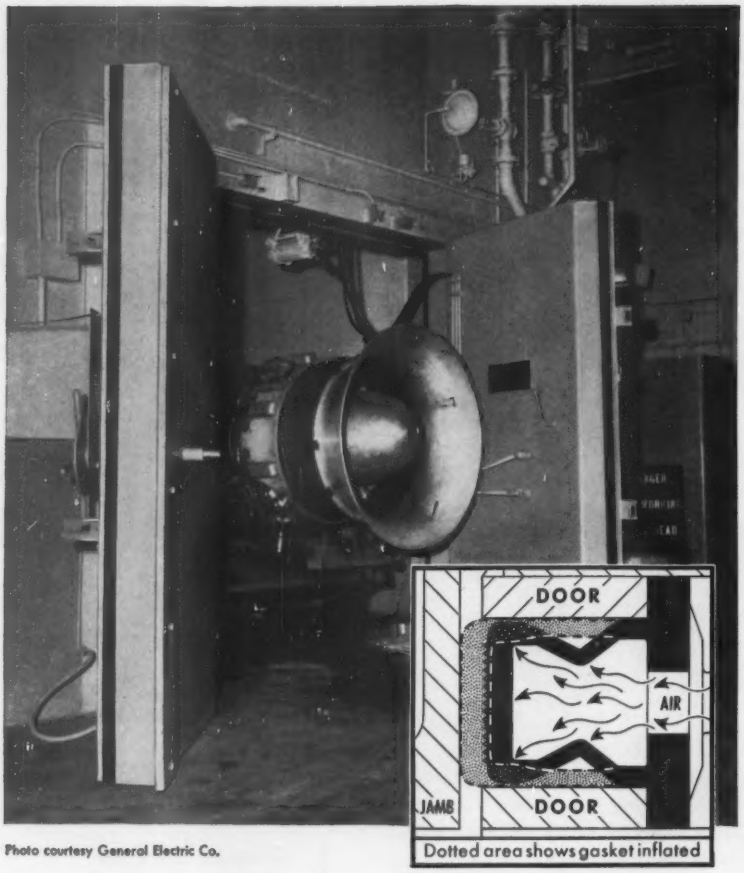

Photo courtesy General Electric Co.

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

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flow in the line in which unit is mounted. Pressure range is 0 to 150 psi. Valve is presently available for ⅜, ½, and ¾-in. air or hydraulic supply lines. **Air Valves Co.**, 24581 Groesbeck Highway, Warren, Mich.

Circle 799 on Page 19

High-Pressure Strainer

for ¼-in. NPS connection

High-pressure strainer for pressures to 5000 psi has ¼-in. NPS male inlet and ¼-in. NPS female outlet connections. Made of stainless steel with 50, 100, or 200-mesh screens, strainer resists all line pressure and conditions. **Spraying Systems Co.**, 3274 Randolph St., Bellwood, Ill.

Circle 800 on Page 19

Brass Fitting

for plastic tubing needs no retightening

Viseal brass fitting designed specifically for plastic tubing makes it possible to obtain complete retention on polyethylene, nylon, and other plastics. Fitting needs no retightening even when subjected to high vibration and internal pressure. Brass insert in one end of tubing holds tube firmly and prevents collapsing. Collet fits over tubing and insert. When nut is tightened, slots in the sleeve allow collet to compress firmly and evenly around tubing, holding it absolutely in place. Design avoids notching, pinching, or cutting of tubing, even when thin-wall polyethylene is used. Design also prevents overtightening and eliminates the need to measure torque or count turns. Fitting can be disassembled and reassembled without need of replacement. It is suitable for use wherever brass is acceptable on air, hydraulic, coolant, fuel, and chemical lines. Fitting can be used in conjunction and interchangeably with copper, steel, and aluminum tubing, providing the same holding power, without notch-

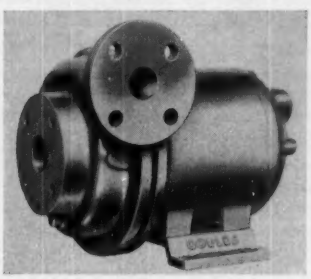
ing or pinching, as with plastic. **Commonwealth Brass Corp.**, 5835 Commonwealth Ave., Detroit 8, Mich.

Circle 801 on Page 19

Centrifugal Pump

is completely leakproof, stainless-steel unit

Sealless (canned) centrifugal pump is available for leakproof handling of volatile, toxic, inflammable, or other hazardous liquids. Positively leakproof, it has no mechanical seal, stuffing box or gland. Motor and pump are combined in an integral unit. Built in two sizes with 1 and 1¼-in. discharge, pumps have a capacity range to 110 gpm, heads to 100 ft, and are recommended for handling clear liquids only. All pumps have a built-in thermal cut-out device that protects motor should winding temperature exceed the maximum safe limit. Pumps are regularly supplied in



318 (CF8M) stainless steel. **Goulds Pumps Inc.**, 203 Black Brook Rd., Seneca Falls, N. Y.

Circle 802 on Page 19

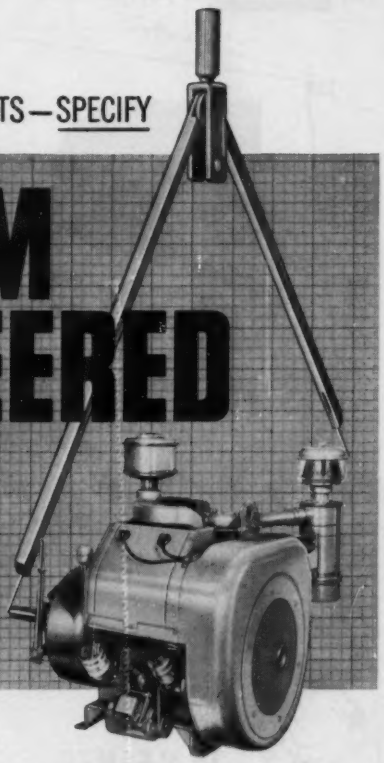
Polyethylene Resin

offers greaseproofness at low coating weight

Petrothene 205-15 polyethylene resin develops maximum adhesion to a wide variety of substrates. It is easily processed and permits excellent heat seals over a relatively wide range of sealing temperatures. Material provides 100 per cent greaseproofness at a lower coating weight than other resins of similar melt index and density. Good coating characteristics of the resin extend to nonporous substrates such as cellophane and foil, as well as to porous substrates. Flow characteristics are well suited for high-speed

IF YOU WANT TO SHAVE TIME AND COST ON YOUR ENGINE-DRIVE POWER PROJECTS—SPECIFY

CUSTOM ENGINEERED POWER BY WISCONSIN



DRIVE TRAIN: specify your choice of centrifugal clutch; over-center clutch; clutch reduction or reduction assembly in a variety of ratios; adaptor to take a spring-loaded clutch or transmission-torque convertor designs.

DIRECT DRIVE: a crankshaft extension to meet your special needs. It's available threaded, tapered, splined, special diameters and lengths, various keys, etc., for close-coupled pumps, generators, and many other machines.

SPEED REGULATION: available in a broad range of governor controls, hand-operated, remote wire-and-lever controls; 2-speed agricultural controls (idle and load speeds) and special provisions to mount controls of your own design.

FUEL SYSTEMS: gasoline, natural gas and LPG (for domestic applications) and alcohol, kerosene, and No. 1 fuel oil (for export).

HYDRAULIC POWER: all Wisconsin V4's can be equipped with integrally-mounted hydraulic pump.

ELECTRICAL EQUIPMENT: electric starter-generator or starter only available for all Wisconsin models, 3 to 56 hp. Solenoid switches and automatic choke, for remote or automatic starting are also available.

SAFETY DEVICES: low oil pressure cut-off switch for 2- and 4-cyl. engines, and high temperature safety switch for all models.

MISCELLANEOUS ACCESSORIES: automotive and spark-arresting mufflers, pre-cleaners, drive pulleys for flywheel, and rewind starters for ACN and BKN engines.

Do you want to see over-all development time and costs drop to management-applauding levels? Then consult Wisconsin *early* in your power-plant design stages.

Wisconsin's unique custom-engineered service provides these two reasons why:

First, its unequalled range of options — covering basic specifications, accessory groupings, and drive variations — permits modification of any production-model engine to meet most installation requirements precisely and economically.

Second, for tougher re-design problems, its engineering counsel draws on more than 50 years of engine specialization to build the perfect partnership between your needs and time-tested features of Wisconsin reliability.

So, if you have a new engine-powered machine on your board, it will pay you to call Wisconsin in the early stages of planning. Send for Bulletin S-249 giving technical details on the complete heavy-duty air-cooled line — 3 to 56 hp. Write Dept. O-10.

WISCONSIN MOTOR CORPORATION

MILWAUKEE 46, WISCONSIN

World's Largest Builders of Heavy-Duty Air-Cooled Engines

Circle 596 on Page 19

put HEINZE in your designs

You profit from exceptional low price and trouble-free performance in Heinze P Motors. These single coil 2 pole induction motors have a wide variety of applications, including pumps, fans, projectors, vending machines, space heaters, toys and appliances. Seven standard models have horsepower ratings of 1/500, 1/375, 1/250, 1/150, 1/100, 1/80 and 1/50 — for continuous duty. They provide slightly better ratings for intermittent duty. Free speed is 3400 rpm. Voltage is 115 or 220, 50/60 cycle. Rotation is CW or CCW.

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HEINZE ELECTRIC COMPANY
685 Lawrence St.
Lowell, Massachusetts

SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

Heinze Electric Company, Dept. D
685 Lawrence St., Lowell, Mass.

Please send catalog on Heinze Sub-Fractional Horsepower Motors.

Name & Title.....
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extrusion coating. Coatings as thin as 0.5 mil can be applied easily. **U. S. Industrial Chemicals Co., Div., National Distillers & Chemical Corp.**, 99 Park Ave., New York 16, N. Y.

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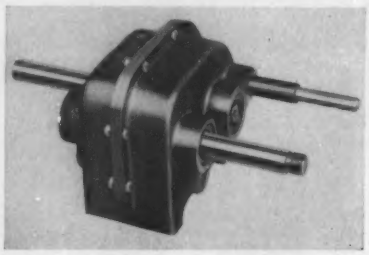
Reversing Transmission

for use on engines to 10 hp



Model P-401 reversing transmission was designed specifically for golf-cart and similar light vehicle applications. Used in combination with a recommended automatic drive on engines to 10 hp, transmission has forward, reverse, and neutral positions. Forward ratio is 3:1, and reverse is 2.4:1. Maximum input speed is 5000 rpm. Input shaft is machined to fit the automatic drive, and output shaft is long enough to mount a brake and drive sprocket. Gears are precision cut, rounded for easy shifting, and hardened. Precision needle bearings and seals are used throughout. **J. B. Foote Foundry Co.**, P. O. Box 2214, Ft. Dearborn Station, Dearborn, Mich.

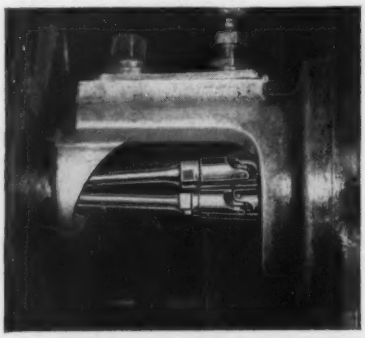
Circle 804 on Page 19

Lubricating Compounds

new line includes
three separate types

Line of antiseize and lubricating compounds includes three separate products, designated Blue Goop, Silver Goop, and High-Purity Goop. Silver Goop prevents seizing and galling regardless of applied load on threaded parts at temperatures to 2100 F. It reduces take-up torque on threaded parts, will not drip off red-hot surfaces nor give off poisonous metal or oxide fumes at high temperatures. It resists water washout. Blue Goop is an antiseize and sealing compound for use on titanium, stainless steel, steel, alu-

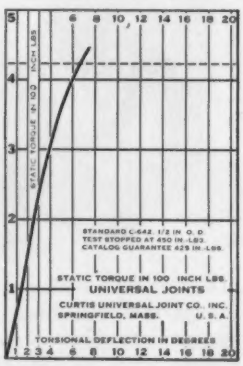
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

Torque Curve ½" Curtis Universal Joint


STATIC TORQUE IN 100 INCH LBS.
TORSIONAL DEFLECTION IN DEGREES
STANDARD C-642 1/2 IN. O. D.
TEST STOPPED AT 450 IN.-LBS.
CATALOG GUARANTEE 425 IN.-LBS.
STATIC TORQUE IN 100 INCH LBS.
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO. INC.
SPRINGFIELD, MASS. U. S. A.

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK CURTIS
UNIVERSAL JOINT CO., INC.
54 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 598 on Page 19

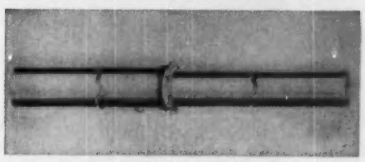
minum and high-temperature alloys. It withstands temperatures to 400 F, and is impervious to water washout, most acids, and all petroleum solvents. High-Purity Goop is an anti-seize and sealing compound for titanium, stainless steel, aluminum, and high-temperature alloys at temperatures to 400 F. Impervious to moisture, high voltage, and cyclic thermal stress, it is recommended for use wherever the prevention of product contamination is essential. **Crawford Fitting Co.**, 884 E. 140th St., Cleveland 10, Ohio.

Circle 805 on Page 19

Hydraulic Cylinders

feature high horizontal stability

Single-acting hydraulic cylinders range from 4 to 18 in. in diameter, in length to suit requirement, and in capacities to 75,000 lb. Featuring high horizontal stability, cylinders are available in operating pressures to 500 psi. Hydraulic piston within steel cylinder moves



on removable precision bronze bearings. Top bolt-ring for attachment to the working surface is standard equipment. **Industrial Div., Joyce-Cridland Co.**, 2027 E. First St., Dayton 3, Ohio.

Circle 806 on Page 19

Thermistor

is sealed in a glass rod

Suited for printed-circuit applications, the 21A7 thermistor is sealed in a glass rod. It has a temperature coefficient of −3.1 per cent C. Cold resistance at 25 C is 100 ohms and drops to about 25 ohms at 50 C. Time constant is 25 sec when suspended by the lead in still air at 25 C. Unit is adaptable to temperature measurement, control, and compensation. **Victory Engineering Corp.**, 536 Springfield Rd., Union, N. J.

Circle 807 on Page 19

Narrower...
for a wider range of
product improvement

NEW
thin-width instrument bearings — standard at MPB — save space and increase power

Featuring a high ratio of O. D. to width, these new MPB high-precision bearings were originally designed for use in synchros of maximum reliability. Further developed under the MPB policy of working with customers to solve miniaturization problems, the thin-width newcomers have proved ideal for servos, potentiometers, gear trains, motors and other instruments.

In applications like these, a thin-width bearing may also function as a motor end cap, while the motor housing serves as the bearing's outer ring seat. This saving of space results in widely varied product improvement. For example, small power units can use the longer stators or rotors without increasing overall unit length or diameter, thus gaining increased power from the same space.

Your own products may gain exceptional, perhaps unexpected, advantages from the use of MPB thin-width bearings. Made to ultra-precision tolerances of ABEC Class 7, they are available in nine sizes, with O.D.'s from .2750″ to .5000″ and bores .0937″ to .1875″. The new thin-width instrument bearings are not "Specials"; they are a standard series without price premium.

An MPB Sales Engineer will be glad to discuss your application with you. For engineering assistance and/or new bulletin write to Miniature Precision Bearings, Inc., 104 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

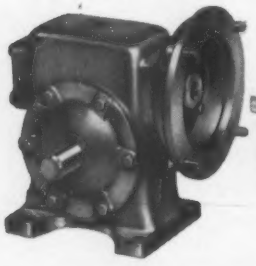
Circle 599 on Page 19

956

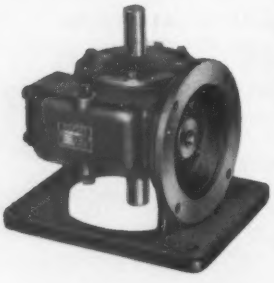
different
motorized
speed reducers

available from stock

Yes! 956 different combinations of Perfection Motorized Worm Gear Speed Reducers are available for immediate delivery, *from stock.* Ratios range from 5 to 1 to 60 to 1, in capacities from 1/6 H.P. to 5 H.P. Perfection "C" Flange Reducers may be ordered complete with motor or without motor, to be used with a motor *of your own choice.*



Flanged motor reducers offer the maximum in compactness, rigidity and adaptability. Through the use of standard NEMA face mounted motors, complete interchangeability between motors is provided. Motor maintenance is possible without disturbing the drive and reducer. Motor assembly is fast and positive with no alignment problems.



Write for your free copy of our new 28 page catalog containing illustrations, charts and tables to help you choose the right Reducer for your particular application. Ask for Bulletin No. M-140.

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AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY, HARVEY, ILLINOIS

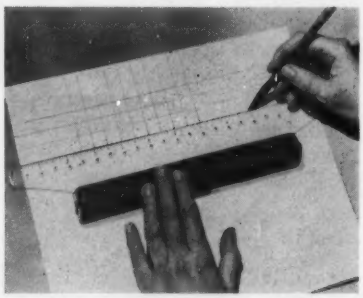
ENGINEERING DEPARTMENT

EQUIPMENT

Ruling Instrument

combines triangle, T-square and parallel rulers

Calibrated ruling instrument, Rol-Ruler, combines triangle, T-square, and parallel rulers to provide fast vertical, horizontal, and diagonal parallel-ruling. Built-in rollers allow smooth, easy movement up or down when drawing lines. Spiral index window automatically measures distances between horizontal



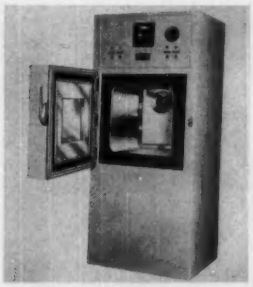
lines as close as 1/16 in. Circles and arcs to a diameter of 22 in. are easily made. Ruler is lightweight virgin plastic. **Rol-Ruler Co.**, P. O. Box 164, Riegelsville, Pa.

Circle 808 on Page 19

Environmental Test Cabinet

for low-temperature use

Com-pac Cab environmental test cabinet has "add-on" facilities for altitude, vacuum, humidity, and temperature testing. Designed specifically for effective low-temperature operation with an adjustable temperature range from −120 to +300 F, it functions with complete dependability for varied testing by merely adding optional equipment. Working chamber is 19 x 19 x 19 in. It is electrically welded and resistant to high pressures. Unit has sealed-in oil supply and built-in thermal-overload protector. Over-all dimensions are 74 x 32 x 32 in. Electrically powered by a 230-v, 60-cycle, single-phase motor, it can be



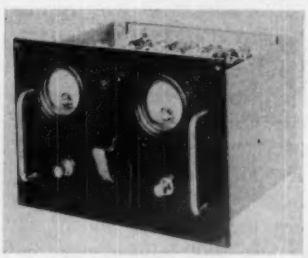
ordered as a horizontal or vertical free-standing floor unit or for bench use. **Hudson Bay Co., Div., Lab-line Inc.**, 3070-82 W. Grand Ave., Chicago 22, Ill.

Circle 809 on Page 19

DC Power Supply

is small, highly regulated unit

Transistorized dual-output dc-to-dc converter, M-1520, only 10½ x 7⅛ x 6 in. in size, has line static regulation of ±0.1 per cent for changes from 27.5 to 31.5 v. Line dynamic regulation is ±0.05 v for input transients of 70 v dc with a duration of 0.2 sec. The unit also features static load regulation of ±0.4 per cent for changes from no load to full load, and load dynamic regulation of ±0.125 v for step changes from no load to full load and full load to no load. Completely transistorized circuit uses several transistorized amplification stages. Automatic current limiting makes the



unit short-circuit-proof. **Perkin Engineering Corp.**, 345 Kansas St., El Segundo, Calif.

Circle 810 on Page 19

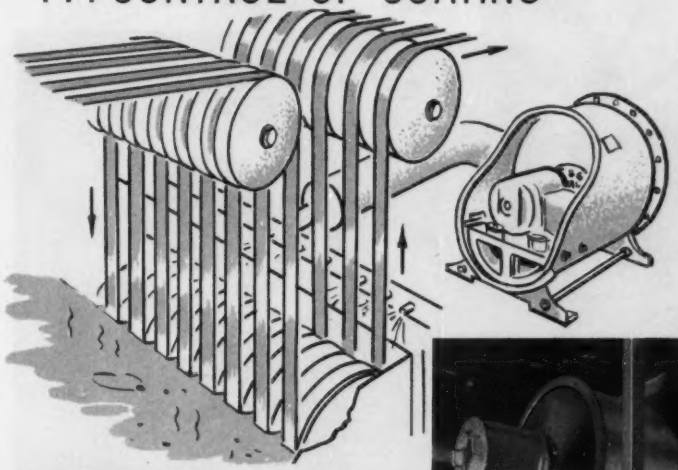
Analog Computer

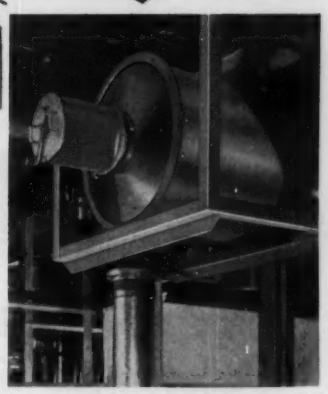
table-top unit
contains 4 to 32 amplifiers

Model AD-1 table-top analog computer solves all types of mechanical, electrical, and industrial problems

The problem in planning production equipment at Stanley Steel Strapping

. . . CONTROL OF COATING





SPENCER BLOWERS
supplied the sensible solution

As a final operation in the finishing of steel strapping, it is necessary to lightly and evenly coat the strapping with wax. The obvious problem: how to control the amount of wax . . . specifically, how to prevent coating too *heavily*.

Incorporating a Spencer blower into the equipment solved the problem. Through a special nozzle arrangement, high volume, low pressure air is delivered against the strapping as it emerges from the final automatic dipping. Excess wax is blown off (and back into the tank) . . . thus reducing costly waste and providing precise quality control of the finished product.

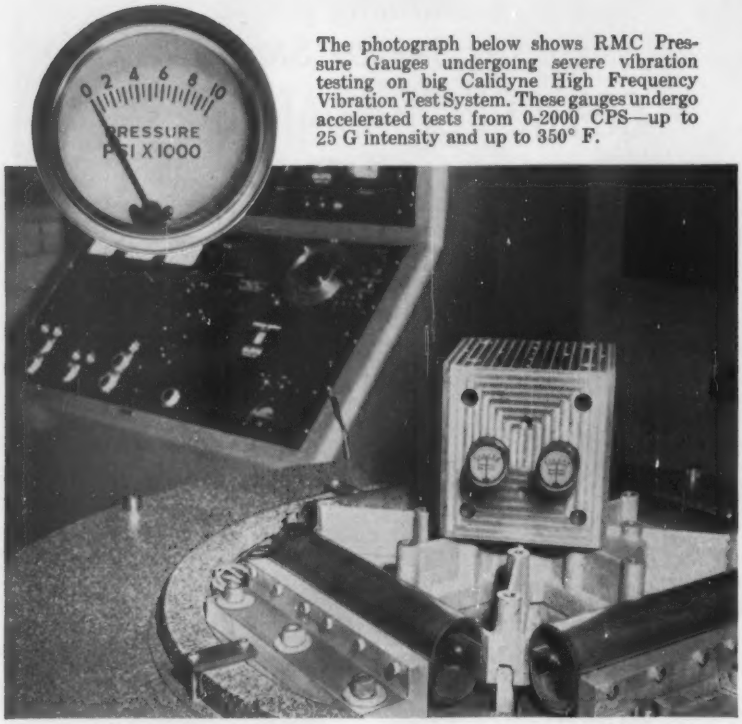
Spencer will be glad to assist in adapting standard blowers —or developing special units—to meet *your* particular needs.

Request Catalog #126B containing complete specifications on Spencer blowers, available in standard capacities of:
½ to 1,000 H.P.
Up to 20,000 C.F.M.
4 oz. to 10 lbs. pressure

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Circle 601 on Page 19

The photograph below shows RMC Pressure Gauges undergoing severe vibration testing on big Calidyne High Frequency Vibration Test System. These gauges undergo accelerated tests from 0-2000 CPS—up to 25 G intensity and up to 350° F.

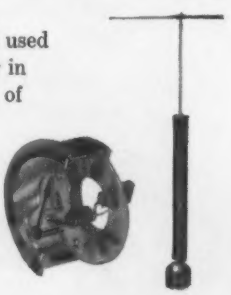


RMC *direct-drive* Pressure Gauge eliminates vibration problems

The RMC *direct-drive* Pressure Gauge is rugged and resilient. It is the first direct-drive helical bourdon gauge—inlet pressure acts directly on a helical bourdon to drive the pointer. The helical coil, as a simple spring, is resilient and fully balanced, and is not affected by shock or vibration.

With its direct drive, there are no gears or linkage to gyrate and score on vibration—no unbalanced bourdon "C" springs and hair springs to whip. Direct-drive action means a stable pointer—no loss of power, too. Pointer action of the RMC gauge is steady, positive and alive—no need to tap the gauge to read. Soft hair springs and backlash springs are not used.

Shown at far right is the pointer-coil unit used in 3″ and 5″ concentric models. The pointer in these models is attached directly to the end of the pressure element. At the near right is a cutaway view of the compact 1½″ and 2″ eccentric models. The pointer in these models is actuated directly by a simple pivot. Both types offer the same direct-drive, helical bourdon advantages. Pressure ranges from 0-1000 to 0-10,000 psi.

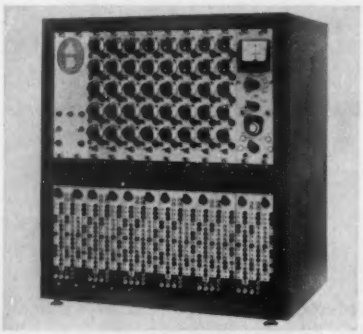


Write, wire or phone for general catalog. If yours is a special application, tell us your requirements—RMC engineers will work with you in solving it. Rochester Manufacturing Co., 229 Rockwood St., Rochester 10, N. Y. (Telephone: BRowning 1-2020).

RMC

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC., Rochester, N.Y.



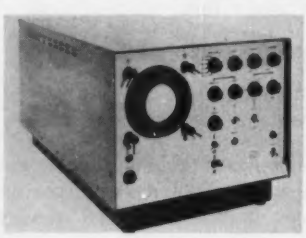
which can be translated into mathematical data. Basically it contains from 4 to 32 amplifiers, depending upon application, providing excellent flexibility. Modules can be used to expand the unit to a full complement of 64 amplifiers. Computer contains simultaneous overload-balance indicators on all amplifiers, which provide for continuous and total monitoring of the circuits. All integrating capacitors, matched feedback resistors, and summing resistors are built into the computer. **Applied Dynamics Inc.**, P. O. Box 2068, Ann Arbor, Mich.

Circle 811 on Page 19

High-Speed Oscilloscopes

detect phenomena lasting only 2 billionths of a second

Model 707 and 708 Milli-Mike high-speed oscilloscopes are traveling-wave, deflection-type units which display both single transient and repetitive phenomena in the millimicrosecond and submillimicrosecond regions. Units have an extremely high frequency response. Bandwidth is rated at dc to 2000 megacycles, usable to 3000 megacycles, and rise time is 0.2 millimicrosec. Six calibrated sweep speeds are available for operation from 5 to 3000 millimicrosec in the unmagnified condition. Display area can be carried from 1 x 1.5 cm at 20 kv to approximately 3 times this size at 3 kv. All controls are



located on the front panel for easy operation. Magnifier control adjusts the size of the display image. Model 707 has a sensibility of 55 mv per trace width and a spot size of 0.002 in. The 708 has a sensibility of 5.5 mv per trace width and a spot size of 0.0015 in. **Edgerton, Germeshausen & Grier Inc.**, 160 Brookline Ave., Boston, Mass.

Circle 812 on Page 19

Wall File

for storing large sheet materials

Martin sheet-file system is a wall-type file for handling and storage of blueprints, drawings, and other large sheet materials. Each sheet hangs flat, requiring less storage space and eliminating curl. Steel-tube frame is hinged to a plywood mounting panel, with locking hinge support arms. Rubber-tipped lock-

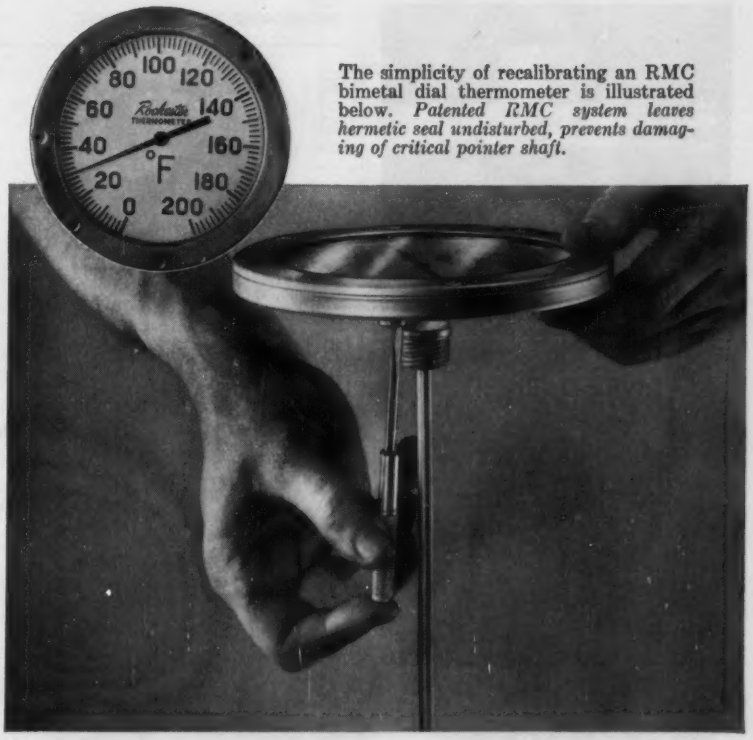
clips are used to mount sheets in the clamp hangers. Many prints can be clamped firmly in each hanger and can be removed easily at any time. Model 30 holds sheets up to 30 in. wide, and Model 42 holds sheets to 42 in. wide. **Lewbill Industries Inc.**, 61 Spring St., Scottdale, Pa.

Circle 813 on Page 19

Voltage Reference Source

has all solid-state circuitry

Precision voltage reference source for calibration of telemetry, data-reduction, and laboratory equipment is available in portable and rack-mounted designs. Incorporating all solid-state circuitry, unit weighs only 8 lb. Basic unit is a four-decade, direct-reading device with full scale of plus or minus



The simplicity of recalibrating an RMC bimetal dial thermometer is illustrated below. *Patented RMC system leaves hermetic seal undisturbed, prevents damaging of critical pointer shaft.*

RMC external recalibration device saves time and your thermometer

With the patented RMC dial reset screw you can recalibrate your thermometer easily and safely, should it ever be necessary. The all-important hermetic seal cannot be destroyed, and there is no chance for damage to the critical pointer shaft.

What the RMC system of recalibration means to you

Sometimes it is necessary to recalibrate industrial thermometers due to severe shock from rough handling, or to calibrate for extreme accuracy at any point on the scale for special work range.

Various recalibration systems are employed in the different makes of ordinary bimetal thermometers. Most all of them will achieve the desired recalibration, but a number of undesirable things may also result. In some, all semblance of air-tight seal is automatically destroyed in removal of the dial glass. In others, the critical pointer shaft may become bent or twisted. And still others use a mechanism incapable of holding the new setting for any length of time. *None of these things can possibly happen with RMC's patented recalibration device.*

A simple dial-reset screw, located on the back side of RMC thermometers, permits recalibration without opening the instrument in any way—thus leaving its air-tight hermetic seal intact. Its positive meshed-gear mechanism rotates the dial itself in a way that cannot under any circumstances cause damage to the pointer shaft. And the new setting will hold indefinitely.

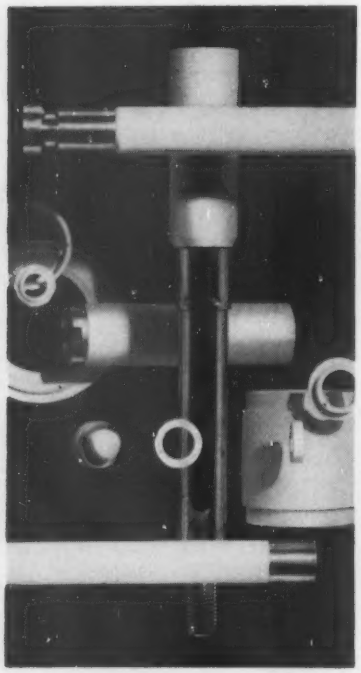
Write, wire or phone for general catalog. If yours is a special application, tell us your requirements—RMC engineers will work with you in solving it. Rochester Manufacturing Co., 229 Rockwood St., Rochester 10, N. Y. (Telephone: BRowning 1-2020).

RMC

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC., Rochester, N.Y.

Circle 603 on Page 19



Coors

Alumina Ceramics Replace Expensive Metals for Vital Pump Parts

The destructive twins—corrosion and abrasion—have led pump designers to use Coors High Strength Alumina Ceramics for the vital parts of pumps, such as plungers, cylinder liners, seal faces in mechanical shaft seals, shaft protection sleeves, and ball check valves.

Perhaps your abrasive and corrosive problems can be solved economically with Coors Ceramics. We shall be glad to help you—just write us at Golden or contact one of our regional sales managers.

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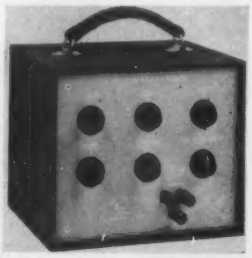
Coors

COORS PORCELAIN COMPANY

600 Ninth St. Golden, Colorado

Circle 604 on Page 19



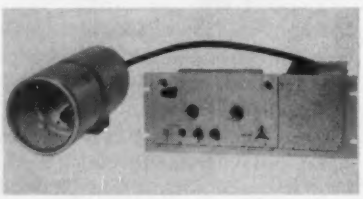
11.111 v in 1.0-mv steps. Inherent noise, drift, and ripple are below 100 mu v. Output impedance is less than 50 milliohms. **Electronic Development Corp.**, 423 W. Broadway, Boston 27, Mass.

Circle 814 on Page 19

Television Camera

is totally transistorized, modular unit

Rugged television camera withstands weather, shock, vibration, noise, salt spray, dust, and other extremes of environment without an auxiliary protective housing. Available for military requirements, it is also applicable for wide industrial use. Model RGS-10 consists of a camera and camera control capable of being operated up to 2000 ft apart. Weighing only 16 lb, camera is 16 in. long and has $6\frac{7}{8}$ in. diam. Camera control is 7 x 19 in. and weighs approximately 15 lb. System is totally transistorized. It employs modular construction, using plug-in transistorized printed-circuit modules, each representing a particular function of the camera. Provision is made for the selection of manual or automatic light-level compensation. Automatic setting self-adjusts the camera circuits for



light-level changes over a range of 2000:1. **Dage Television Div., Thompson Ramo Wooldridge Inc.**, Michigan City, Ind.

Circle 815 on Page 19

BUILD A BETTER PRODUCT, MAINTAIN QUALITY, CUT COSTS.....
USE
MERRIMAN POWDERED METAL PARTS

PRECISION MADE —
HIGHEST QUALITY —
DIMENSIONALLY PERFECT

Merriman, originators of sintered helical gears, offer high density, precision structural parts from powdered metal in Brass, Bronze, Copper, Nickle Silver, Steel, Iron and Iron Alloys. Complete design and engineering service available.

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MERRIMAN BROS., INC.
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188 Amory Street, Boston 30, Mass.

REPRESENTATIVES IN PRINCIPAL CITIES

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793 Laurelton Rd. Rochester 9, N.Y.
26018 West Seven Mile Rd. Detroit 19, Mich.

Circle 605 on Page 19

THE ENGINEER'S

Library

Recent Books

Fluid Power Control. *Edited by John F. Blackburn, Gerard Reethof, and J. Lowen Shearer;* 710 *pages,* 6¼ *by* 9¼ *in., clothbound; published jointly by the Technology Press of M. I. T. and John Wiley & Sons Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.; available from* MACHINE DESIGN, $17.50 *per copy postpaid.*

Presented are the fundamentals of operation of power-control systems in which the working media may be either liquids or gases. Analytical and experimental approaches to the understanding of fundamentals are covered.

Emphasis is placed on the conversion, transmission, and control of fluid power under conditions for which gravitational effects are negligible. Some topics discussed are the flow of fluids through closed conduits, orifices, and valves; variable-volume chambers, pumps, motors, and accumulators.

The Design and Construction of High Pressure Chemical Plant. *By Harold Tongue;* 250 *pages,* 8 *by* 10½ *in., clothbound; published by D. Van Nostrand Co. Inc.,* 120 *Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, $15.00 *per copy postpaid.*

Statutory requirements for design and operation of pressure plant, fundamentals of pressure measurements, and general principles of design and construction of high-pressure equipment are thoroughly covered in this second edition. New developments since the 1934 edition include applications of high-pressure technology to petrochemical-plant design, and design of reactors and auxiliary equipment for nuclear power plants.

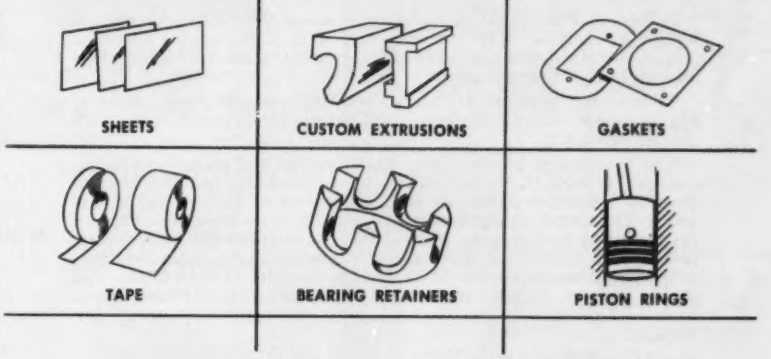
The Internal-Combustion Engine in Theory and Practice: Volume I. *By Charles F. Taylor, professor of automotive engineering, Massachusetts Institute of Technology;* 574 *pages,* 6 *by* 9¼ *in., clothbound; published jointly by The Tech-*

BASIC SHAPES AND FABRICATED PARTS IN

RULON®

REINFORCED TFE RESIN*

*Dupont Teflon



Design engineers note! RULON adds extra values to your products . . . low friction performance even without lubrication . . . wide temperature adaptability (−350° to +500°F) . . . high resistance to wear and deformation . . . and practically universal chemical inertness. Unlike nylon and many other materials, RULON won't swell in presence of moisture.

RULON is the sure relief to many a design headache. For RULON engineering Brochure #9572, write

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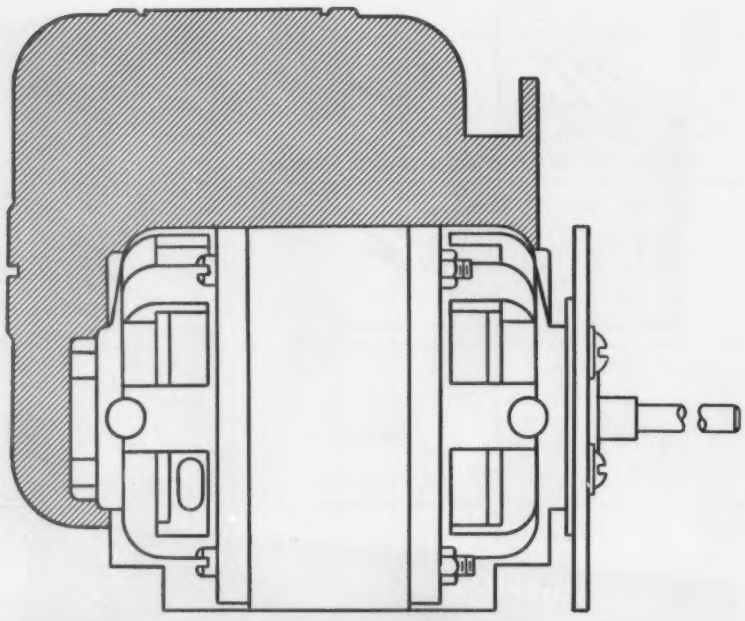
Circle 606 on Page 19



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nology Press of M. I. T., and John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from MACHINE DESIGN, *$16.00 per copy postpaid.*

This first volume of a two-volume work is devoted to establishing a quantitative background for new design and development, and for the proper evaluation of the performance of contemporary internal-combustion engines.

Thermodynamics, fluid flow, and performance are thoroughly discussed. Data furnished in numerous tables and charts are ready for direct application, independent of units of measure or cylinder size.

Motor Selection and Application. *By Charles C. Libby; 486 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$13.50 per copy postpaid.*

Motor selection in terms of load characteristics, service requirements, space limitations, duty-cycle requirements, and safety is explained. A minimum of advanced mathematics and electrical theory is presented in the explanation.

Over 290 charts, tables, and illustrations relate load variables to motor characteristics, and enable the user to achieve the best maintenance electrical equipment for the task to be performed. Data include industrially acceptable standards of ASA, AIEE, and NEMA which apply specifically to integral-horsepower polyphase motors and dc motors.

New Standards

ASTM Standards on Copper and Copper Alloys. *720 pages, 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $7.50 per copy.*

This 1959 compilation contains 137 standards of which 17 are new, revised, or have had their status changed since the previous edition in 1957. In addition to standards for cast and wrought copper and copper alloys, there is information on nonferrous materials for electrical conductors, and selected specifications on nonferrous metals and alloys for primary forms of copper,

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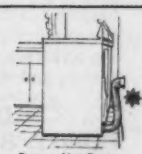

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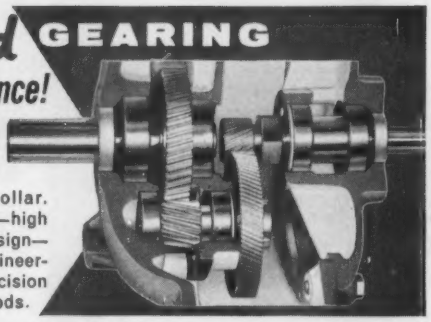

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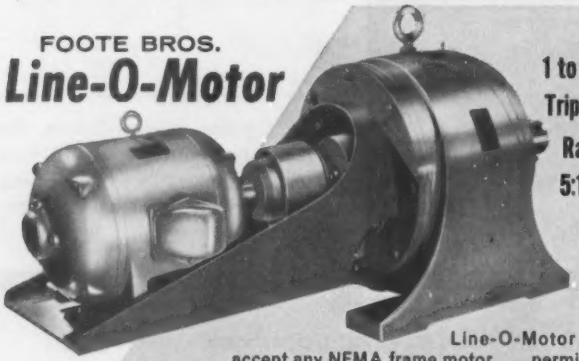

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ASTM Standards on Metallic-Coated Iron and Steel Products. *176 pages, 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $3.50 per copy.*

This second edition is virtually a complete revision of the first edition issued in 1956. Of the 34 standards, all but 5 have been newly added, revised, or changed in status.

Among the materials covered are zinc-coated wire, strands, fencing, sheets, pipe, and hardware. Also included are aluminum-coated wire, aluminum-coated iron and steel articles, and terne - alloy - coated sheets.

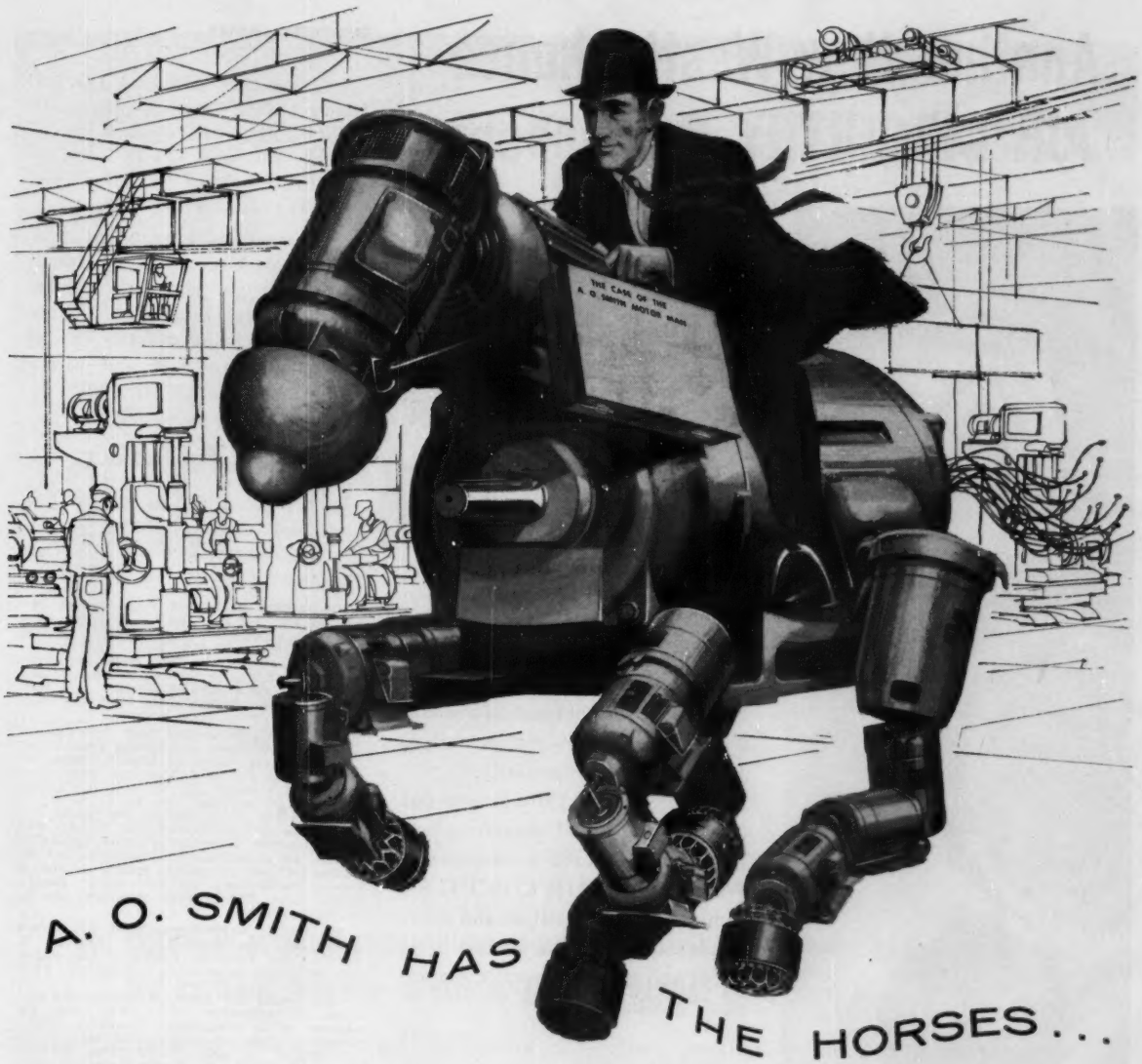
Association Publications

Gas Shielded-Arc Welding Processes. *Edited by Arthur L. Phillips; 78 pages, 6 by 9 in., paperbound, stapled; published by and available from American Welding Society, 33 W. 39th St., New York 18, N. Y.; $1.50 per copy.*

A comprehensive discussion of various gas shielded-arc welding processes is presented. Included is information concerning selection of welding methods for particular applications.

Plastics Engineering Handbook. *565 pages 7 by 10¼ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y; available from The Society of The Plastics Industry Inc., 250 Park Ave., New York 17, N. Y.; $15.00 per copy.*

Revised and expanded, this third edition contains an extensive treatment of the plastics-engineering field. Nomenclature, molding, extrusion, standards, and reinforced plastics are discussed. Design standards for inserts and design of molds and dies are also covered. New material on nomenclature, cellular plastics, decorating, welding, and plastics as adhesives is presented.



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Circle 610 on Page 19

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Iron and Steel Section of 1960 SAE Handbook (SAE TR-30). *173 pages, 8½ by 11 in., paperbound; available from Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; $7.00 per copy.*

A comprehensive treatment of ferrous metals is presented. Thoroughly covered are chemical compositions, physical properties, numbering system, testing methods, threaded fasteners, castings, and various ferrous materials.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151703. Mechanical Properties of 17-7 PH and PH 15-7 MO Stainless Steel. By Alton W. Brisbane, WADC; 38 pages, 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.

Tensile stress-strain tests were run from room temperature to 1000 F, and compression and bearing data were obtained at room temperature. Test results were compared with similar data from other materials.

PB 151867. Theoretical and Experimental Studies of the Stress and Strains around Cutouts in Loaded, Unevenly Heated Plates. By P. C. Huang and C. J. Van Der Maas, Martin Co.; 173 pages, 8¼ by 10¾ in., paperbound; $3.00 per copy.

Development of a method for stress and strain analysis of heated flat plates with square cutouts is explained. The method is verified by comparison of theoretical and experimental data in which general trends of strain distributions are the same. Experiments using 2024-T4 bare aluminum are reported in detail.

PB 161017. A Bibliography on Gas Lubricated Bearings—Revised. By Eugene B. Sciulli, The Franklin Institute; 107 pages, 8½ by 11 in., paperbound, side-stapled; $2.50 per copy.

This revised and expanded bibliography contains 290 references (more than twice the number of its predecessor, December, 1957). Where possible, an abstract of each article is included. A new subject index contains thirteen headings specifically chosen to cover the many varieties of gas-lubricated bearings.

PB 161035. Stress Distribution in a Plate with a Hole Subjected to an Axial Load and Creep. By Joseph Marin, The Pennsylvania State University; 21 pages, 8¼ by 10¾ in., paperbound, stapled; $0.75 per copy.

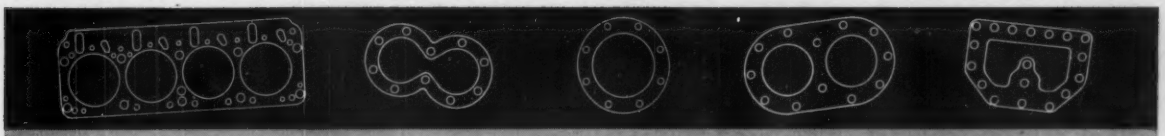
To evaluate the creep in a riveted joint, the creep of component parts were considered. Creep stresses in an axially loaded plate with a hole were determined together with stresses in the rivets. An approximate analysis of the stresses is presented.

PB 161036. Creep Deformation in a Single Riveted Structural Joint under Axial Tension. By Joseph Marin, The Pennsylvania State University; 14 pages, 8¼ by 10¾ in., paperbound, stapled; $0.50 per copy.

Outlined is a procedure for theoretically predicting the creep deformation of a single riveted joint. This procedure considers the creep from the component-parts viewpoint rather than the conventional approach which uses the over-all creep as the criterion for deformation prediction.

PB 161051. The Development of Oscillatory Plain Bearings and Lubricants for Airframe Applications in the Temperature Range —90 F to 1500 F. By W. A. Glaeser, C. M. Allen, W. J. Zielenbach, and W. H. Goldthwaite, all of Battelle Memorial Institute; 62 pages, 8¼ by 11¾ in., paperbound, stapled; $1.75 per copy.

Materials that showed promise as airframe journal bearings in the —90 to 1500 F range were developed and evaluated under simulated operating conditions. Bearing operation became oscillatory at 15 cpm. Promising shaft and bushing materials were found for temperatures up to 1500 F. A high-temperature lubricant was developed and showed promise in the 800 to 1200 F range at bearing loads up to 25,000 psi.



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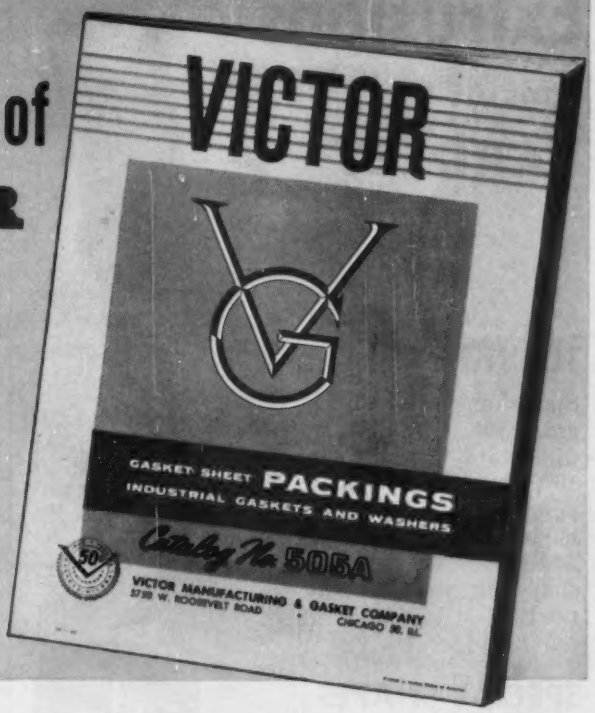

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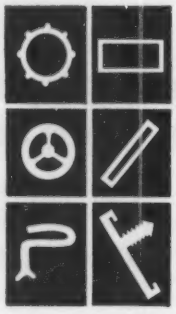

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Professional Viewpoints

. . . qualified to design . . .

EDUCATION for design engineering, the subject of our March 3 editorial, quite naturally is of concern to a good many MACHINE DESIGN readers. Colin Carmichael's invitation to write to us and share opinions on the subject brought a gratifying response. Here are some of the letters we received.

To The Editor:

I was very much interested in your editorial entitled "Qualified to Design." I think you have hit the nail on the head. Of the many engineers we interview each year I would guess that 80 per cent express a desire to go into development or research work, and a great many stipulate that they would *not* want to take a job in "design" if it were offered to them. Apparently our educational courses leave the impression in the minds of engineers that all design work is lettering, looking up standard parts like screws and bolts, taking many hours to put on a sheet of vellum what an engineer can visualize in five minutes, etc.

Naturally, as in all fields, a training and orientation period is necessary, but there are tremendous opportunities in the design area for qualified engineers—partly because so few are interested in it.

The design engineer, by the very nature of his work, has close contact with tooling people, sales personnel, industrial designers, purchasing executives, accounting and pricing personnel, etc. He usually has many contacts with top management because his decisions directly affect money spent by a company for tooling and for the product itself. He has a very interesting view of the over-all financial operation and has the satisfaction of seeing his work reproduced hundreds of times in production.

Even small design problems, which—to the uninitiated—appear to be very simple, sometimes require a great deal of ingenuity.

It seems to me our educators could well pick some typical design problems encountered in industry—problems which involve financial as well as technical analysis. This would force the student to demonstrate some creative approaches, and it would demonstrate to him that most design-engineering decisions touch all the areas of business. I am sure it would not be difficult for industrial concerns to supply typical examples.

—PAUL W. WYCKOFF
Chief Engineer and Director of Product
Chrysler Airtemp Div.
Chrysler Corp.
Dayton, Ohio

To The Editor:

Your editorial about the teaching of design is a good summary of a bad situation. Unfortunately, there is not much teachable technique involved. A good designer should have ingenuity, self-confidence, some experience in the application at hand, the ability to make drawings (or to direct draftsmen), and precious little else. What is there to teach?

Engineering education and background are helpful, of course, and such things as techniques of approach, familiarity with materials, and mathematics can be useful, but they are very definitely secondary. Good designers, regardless of teaching methods, are never going to be common, but there will probably be enough.

The real problem facing the "good" designer is that he is a thorn in the side of his management. Only the most unusual, or most desperate, executive will fail to dispose of a boat-rocker at the very earliest opportunity, and lo, our hero has received some potent training toward mediocrity.

There is no use bewailing the situation. It has always been that way, and will doubtless remain so. How can our boy get his ideas accepted without ruffling any feathers? There is something worth teaching!

—G. W. Dingus
Design Engineer
Frontier Perforators Inc.
Pampa, Tex.

To The Editor:

Your editorial has properly pointed to the importance of design in engineering by saying that "engineering *is* design." Without design, production, sales, and other branches of engineering would not exist.

Your statement, "Engineering colleges for many years offered little that could really be called education for design," needs an additional interpretation, although it is a true statement.

As a teacher of machine design, I can assure you that colleges provide a good *preparatory* education for what can be called a real education for machine design; without this preparation no real education for design rendered to our prospective engineers by industry could be possible. Basic engineering science courses are steadily "upgraded," but neither teaching nor learning time is correspondingly increased in engineering curricula. As a result, machine-design classes receive students with such a background that they cannot learn real design without first developing certain proficiency in the application of engineering mechanics and, particularly, the strength of materials to elementary single-answer problems.

Also, a special training is necessary in calculation techniques, because "the decision-making activity" is possible and leads to sound design variants only then, if the calculations are accurate. In machine-design classes we must train our students in accurate use of arithmetic because in previous courses they are mainly trained in methods, and little or no attention there is paid to the accuracy of mathematics involved. Working on machine design, we must have exact mathematical results and ability of logical thinking. The

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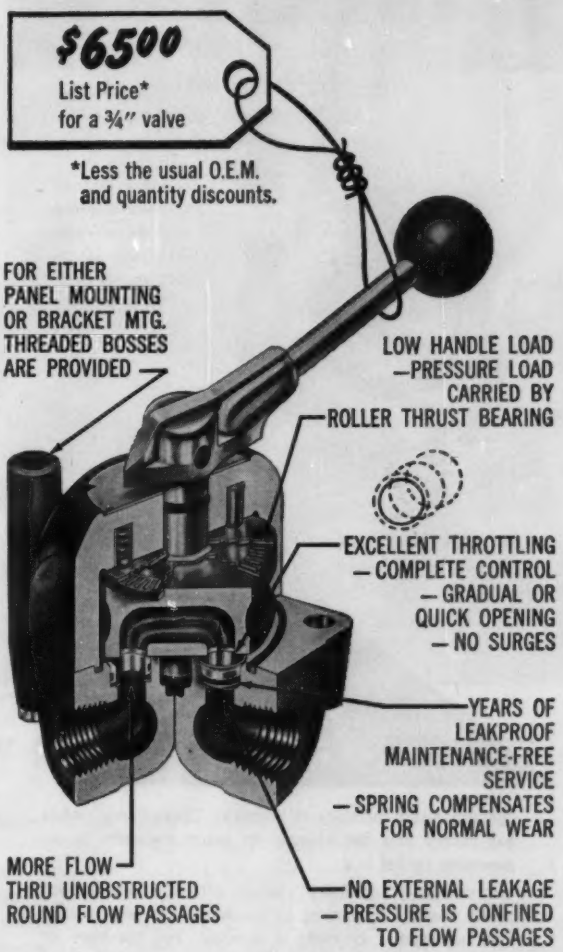
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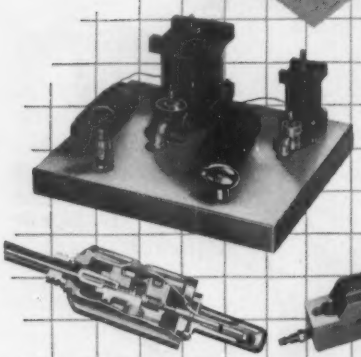

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Double action cylinder with all manually operated valves inside the piston.

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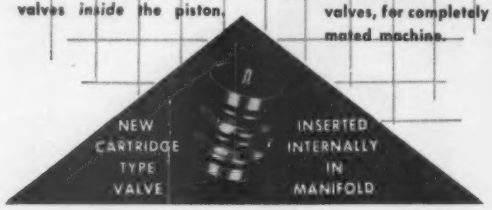

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single-answer problems on machine elements secure the best *preparatory* education for real design because they develop students' ability for logical thinking, if they are sufficiently intricate. Without knowing how to design machine elements, even such simple ones as the nut, no real design education is possible.

He who has done a real design knows how much time must be spent on trial calculations of a multi-answer problem in order to arrive at a reasonable design variant, especially if he is a beginner. Several variants must be worked out and put on "the board," viewed from different aspects, and compared in order to make the final decision in the selection of the best for production. The teaching of real design to a group of students would take still more time.

Do the present engineering curricula provide the necessary time for the real type of design education? Definitely, no! The preparatory work takes all the available time, but without the preparatory work, our present average student cannot be taught real design.

Your magazine, working design engineers, and their managers would render a considerable service if they would persuade our top engineering educators from ASEE and ECPD that more teaching and learning time must be provided for design education in engineering curricula by:

1. Expanding undergraduate studies to five years.

2. Transferring a host of freshman courses to the high school and gradually changing the college admission requirements.

3. Changing drastically the present very rigid mass-production educational system so that each individual student could bring his speed in studies in balance with his attitude, ability, background, and other individual properties involved in the process of learning and required for successful completion of his design and other studies. Students should be allowed to select the individual time necessary for completion of that engineering program which is considered desirable to develop designers' talents. In other words, students should be granted complete academic freedom, and more teaching stimulation must be rendered them by increasing the contact time in our curricula.

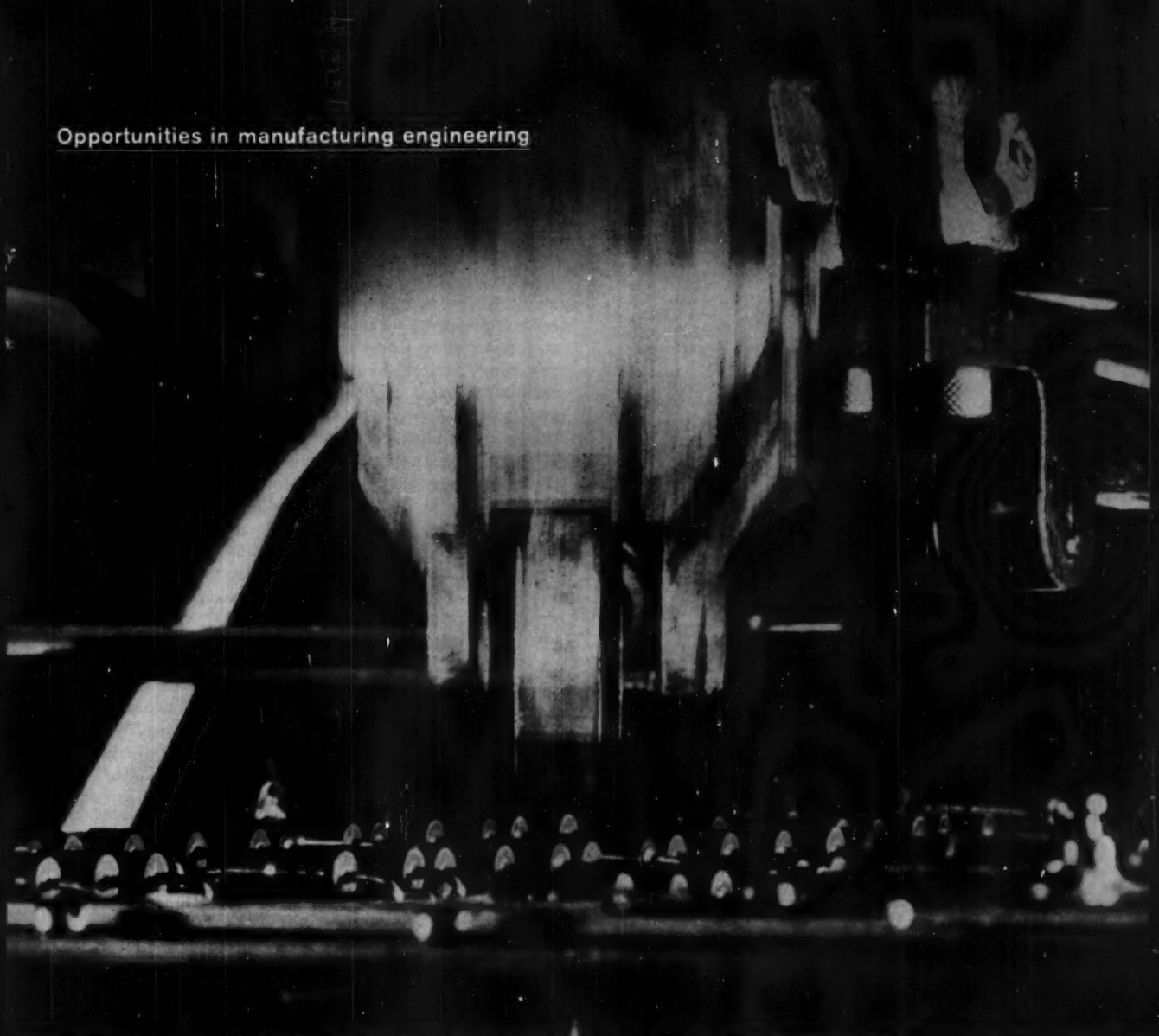
Without extra teaching and learning time, the suggestions that could be received from working designers will be meaningless.

The expression that "a revolution is taking place in colleges" is at the proper place. Revolutions usually run from one extremity to the other. "The old-style design course" is swept out and the real design is taught to inadequately prepared students who do not have sufficient time to learn it.

I would prefer an evolutionary process instead, because I have a serious doubt about the success of the revolutionary procedure, especially since some people dream to develop "men qualified to design—even beyond the frontiers of knowledge" at colleges on undergraduate level. The attempt to develop such super-designers, of course, will fail because even our industry has failed to develop them.

Designers in the rocket and missile field could not avoid a lot of failures, and their successes are based

Opportunities in manufacturing engineering



Programmed Component Inserter developed by IBM engineers working in manufacturing research.

Engineering complete assembly cycles down to 1.2 seconds

In the time it takes you to read this sentence, the Programmed Component Inserter can select, position, insert, and then clinch four or five different electronic components onto a printed circuit board. This system makes possible low-cost assembly of pluggable logic units for computer applications.

How the system works—Assembly instructions are given to the Inserter by a Cardatype® reader which senses the system's punched card input. It then locates the correct position on the board, selects the right component, and inserts and clinches it. The complete cycle takes 1.2 seconds.

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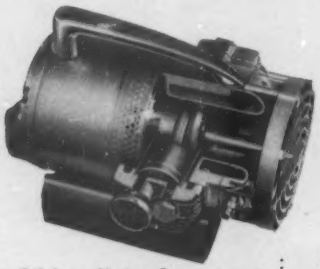
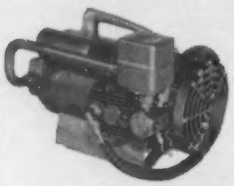
For portable or built-in applications, these lightweight, compact compressors give maximum air per horsepower.



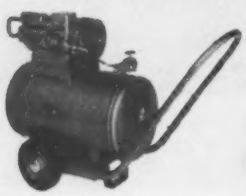
Oil-less Motor Compressor Units—35, 75 and 175 lb., single and two-stage, ¼ to ¾ H.P.

Bare Compressor (less Motor)—35, 75 and 175 lb. pressures, for belt-driven applications.

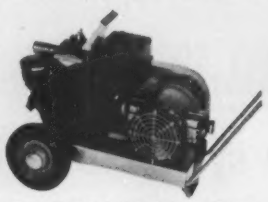


Tankless Motor-Compressor Outfits—for use where existing air tanks or pipe lines provide air storage. 35, 75, 175 lbs., single and two stage. ¼ to ¾ H.P.

"Piggy-Back" Compressor Tank—Handy 2-gallon tank mounts on any B&G 75 or 175 lb. Motor Compressor or Tankless Outfit.



10-Gallon Air Tank Motor-Compressor Outfits. 35—175 lbs.—mounted on Code or non-Code Tanks. Portable when cart-mounted.



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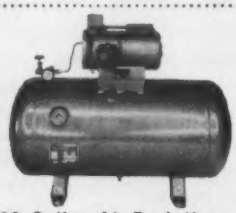

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largely on experiments. Colleges will never have adequate budgets and curricular time to experiment with students' design products in such a "no man's land" in order to explore their practical usefulness.

There is no need to invade the no man's land to teach real design to undergraduates. It can be done on good existing designs. By proper analysis and by comparing several designs of an existing device or machine, students can develop their own design projects, thereby applying available scientific information and demonstrating creativity.

Working design engineers and their managers could render a substantial help to colleges in teaching real design by supplying them with blueprints and assembly or pictorial drawings of their products for students' use. This is common practice in Europe—there industry realizes that it profits from prospective engineers who reach such a level in college that they are able to bring new ideas to their jobs.

—J. H. Inveiss
Dept. of Mechanical Engineering
Michigan College of
Mining and Technology
Houghton, Mich.

To The Editor:

Your editorial prompted the following agreement and, I hope, contribution to the subject, based on both design experience and a sincere interest in motivation toward creativity as related to education.

"How would you go about developing men qualified to design?"

Thomas Edison conceived a generator, radically different. An employed scientist made the calculations, "the single-answer problems." Contemporary scientists, schooled and habituated, were incapable of admitting the innovation into their "gestalt" and denied Edison's claims.

The youngster who builds a wagon of junk-yard parts has begun his preparation to design—making decisions and recognizing the challenge of creative design.

Healthy pre-school children show a great deal of curiosity and initiative; they spontaneously improvise, experiment, and enjoy their little successes! Isn't this fire quenched by eight years of "spooning in" of one-answer problems and other rote learning, and unintentionally forcing on them an excessively dependent role? Can this natural problem-creating and problem-solving be revived suddenly in the years which follow?

The principles of physics (without math problems) were a thrilling revelation to me at age 12 and made a permanent impression. My 17-year-old son, who was mechanically inclined, has cause to hate 15 physics problems which destroy the wonder of the science—the joy of dreaming of its applications!

The dreams will inspire acquisition of the mathematical know-how which is required for "my problem." The inquisitive child becomes the creative designer—provided his curiosity survives schooling.

—S. Beaty Tanner
Kettering, Ohio

To The Editor:

Your remarks in the editorial "Qualified to Design" were of much interest to me. The curriculum of the Department of Electrical Engineering at the University of Cincinnati has courses in design. We hear that this is unusual, however, and so your remark that a "revolution is now taking place in the colleges" is the focus of our interest. Which colleges?

It is my belief that one of the main reasons for design courses being rare in college curricula is that these are more difficult to teach than courses in analysis. With the latter, a novice with a suitable book can do an acceptable job of teaching. In design, the teacher should himself be a qualified designer. An advanced degree or two does not make one a qualified designer. The other characteristic that makes design courses unpopular with both students and teachers is that it is much more difficult to have satisfactory examinations. In analysis, one answer is correct, and this permits rapid grading for those students who have a correct solution. In design examinations, on the other hand, every step must be evaluated, its appropriateness judged, and a grade determined from the general impression of the student's judgment and ingenuity. This takes much more skill on the part of the teacher and even the best qualified may have more doubts about their ability to arrive at a "fair" grade than they do in the analysis courses.

I am not holding that these reasons are sufficient to eliminate design courses as has been done. We have them here! Rather, it is my opinion that colleges should develop teachers who are qualified to design and then such courses are more likely to be included.

—W. H. MIDDENDORF
Associate Professor of
Electrical Engineering
University of Cincinnati
Cincinnati, Ohio

To The Editor:

The first thing the universities should teach is that every good designer is fearless. Then they should spend the student's time to learn only *sources* of required information, not waste time on a lot of information that may never be used. Then they should teach the prospective designer that ingenuity is no more than the effort of the mouse to get at his food in a maze. It seems odd that most of our great inventors were men that never had the opportunity for a formal education. Then someone should teach the educators that the world outside is not all books but down-to-earth common sense in a welter of competition.

Yes, I believe in books, but they all have indexes that give me what I need when I need it. My shelves are full of books, but I can't say I read them through. I do not have the time. I do not believe I could even pass an examination unless I were allowed my shelf of books. To memorize that welter would be silly.

—RAY WILBURTH
Tecreators
Milwaukee, Wis.

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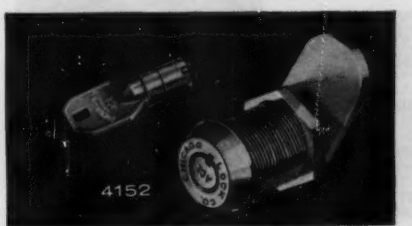

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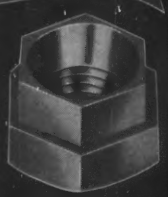

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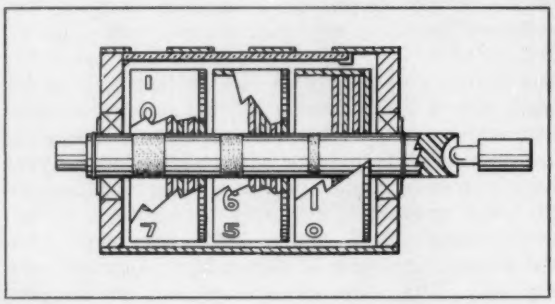
NOTEWORTHY Patents

Dial-Lighting System

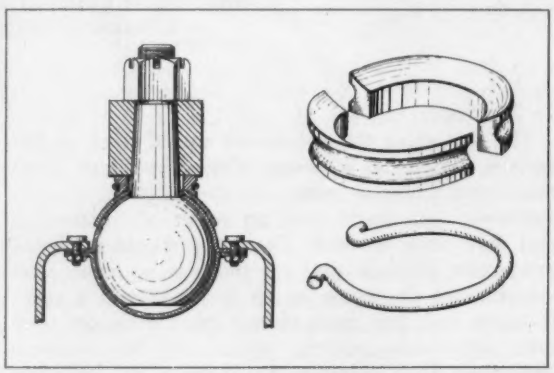
Actuating shaft for drum dials is made of glass or transparent acrylic resin to serve as a "light pipe" for dial illumination. Light enters the shaft from a lamp



at either, or both, of the ends. It is masked from leaving the shaft except at zones where illumination is required. *Patent 2,909,857 assigned to General Precision Laboratory Inc., by George D. Wilson.*

Ball-Joint Preloading Device

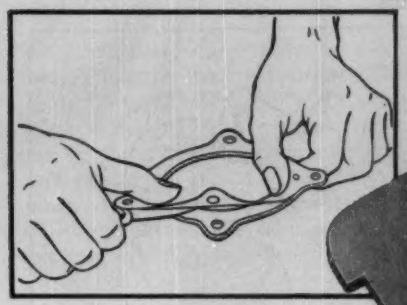
Wedging-action ring segments take up clearances and develop preload on ball-joint assembly. Snap ring in the annular groove on the ring segments maintains

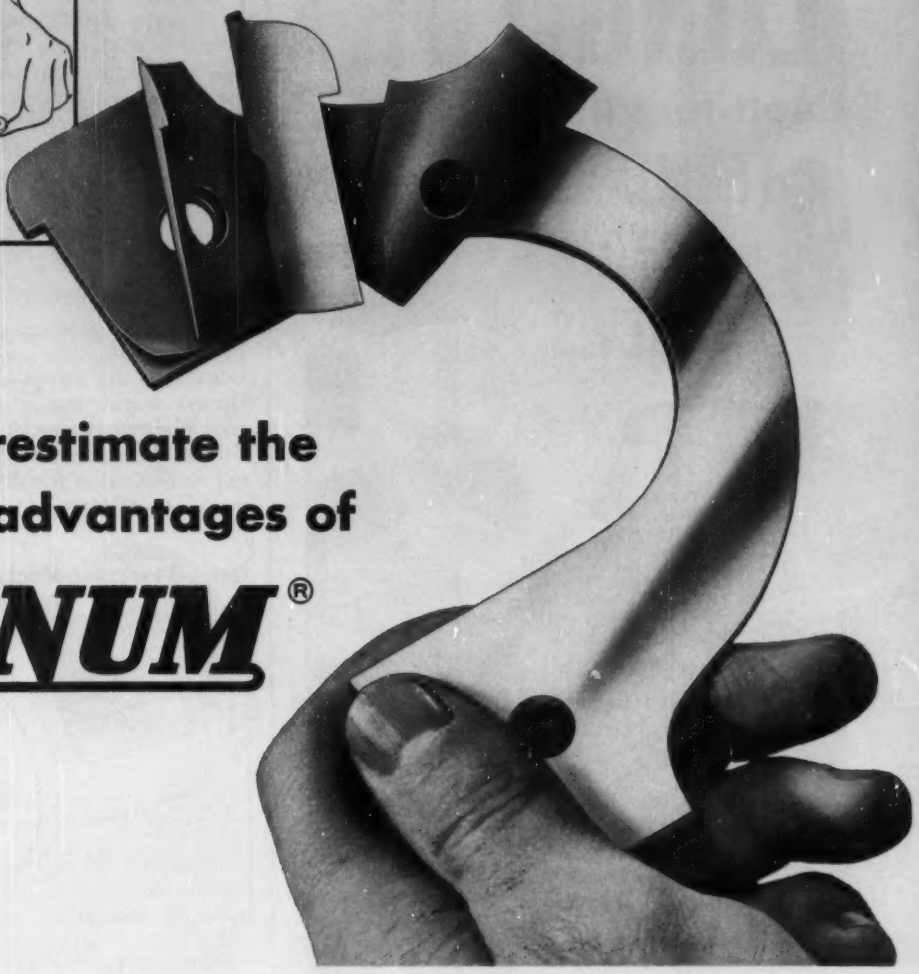


forces radially inward on the segments. The segments serve as a thrust washer between a collar on one side and the spherical ball housing on the other. *Patent 2,911,244 assigned to F. M. Research Corp., Ontario, Calif., by Fred Mineck.*

Low-Shock Geneva Mechanism

Epicycloidal slots instead of the usual radial slots on a Geneva-type mechanism permit smoothly accelerated starting and stopping of the driven member. Positive





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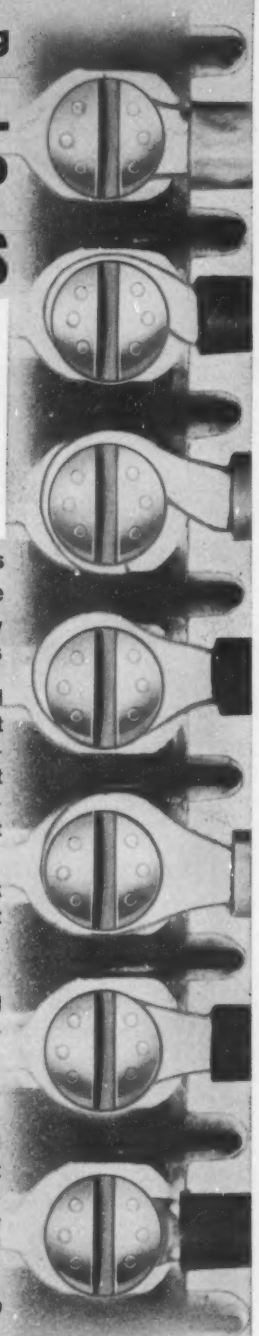

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- Insure reliability of circuits

These specially developed self-locking screws resist shock and vibration, eliminating the possibility of short circuits due to screws working loose. They will not affect conductivity.

Because they eliminate lock washers, they save weight and speed assembly time.

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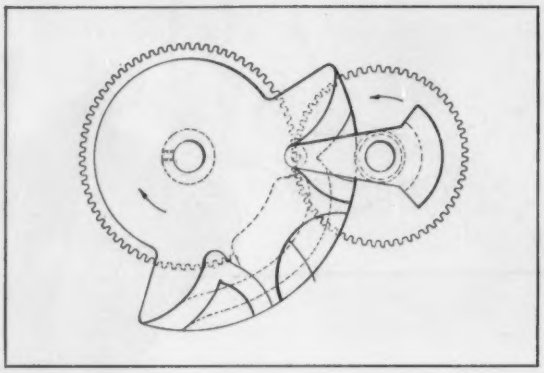
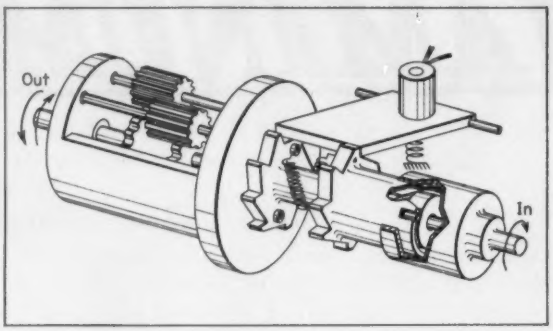


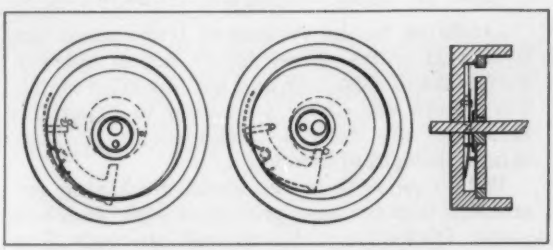
locking of the driven member in the manner of a Geneva mechanism is retained. Other modifications (not illustrated) provide for one or more full revolutions of the driven member in response to one or more full revolutions of the driver. *Patent* 2,918,828 *assigned to Barkely & Dexter Inc. by Robert G. Dexter.*

Quick-Reversing Mechanism



Planetary gearing and an overrunning clutch form the basic elements of an inline reversing mechanism. Quick reversing is attained with electromagnetic solenoid control of a ratchet mechanism. With the ratchet engaged, the clutch is disengaged to permit normal operation of the planetary gearing. Output and input rotations are opposite in direction. When the ratchet is disengaged, the clutch engages to lock up the planetary gearing for straight-through drive. *Patent* 2,905,023 *assigned to Collins Radio Co., Cedar Rapids, Iowa, by Glen B. Morris.*

Limit-Stop Mechanism

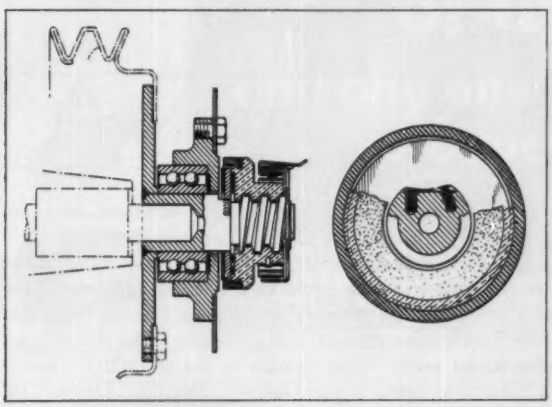


Two pins actuate a spring-loaded lever to limit angular travel of rotating shaft in either direction. A

disc, mounted eccentrically to the shaft being controlled, engages the inner surface of the housing. As the shaft rotates in one direction the disc rotates in the opposite direction. At one angular position of the disc, a pin on the disc actuates the lever which engages a second pin on the eccentric element to stop rotation. Geometry of the design may be modified to vary number of revolutions between stop positions. *Patent* 2,903,893 *assigned to the Perkin-Elmer Corp., Norwalk, Conn. by Larkin B. Scott and Rudolf Losch.*

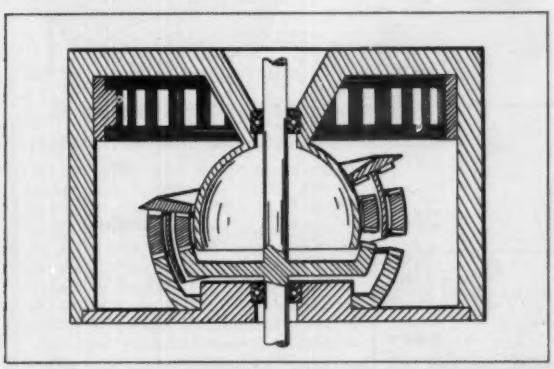
Thermostatically Actuated Clutch

Spiral-wound bimetal element locks or unlocks driven and driving elements in response to temperature variation. Holes in the cup enclosing the bimetal element

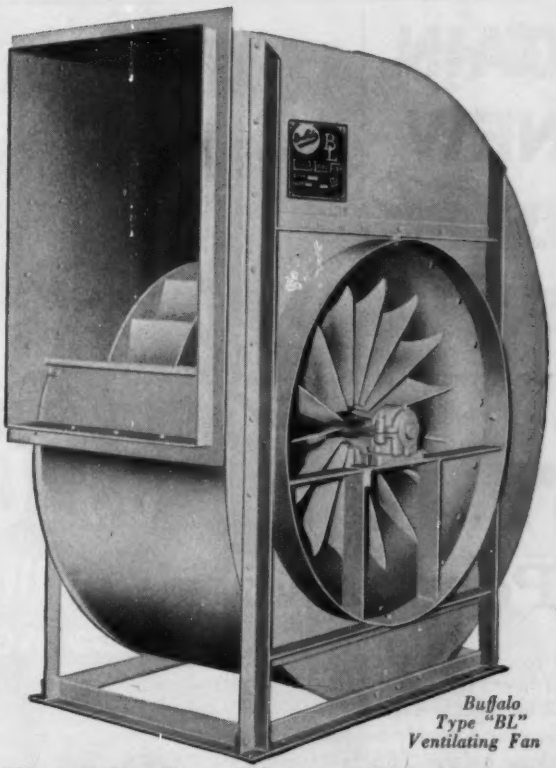


permit free circulation of air over it. Expansion of the bimetal causes a plastic nut to rotate on a screw. Relative axial displacement of nut engages or disengages mating friction surfaces on the driving and driven members. *Patent* 2,925,158 *assigned to Borg-Warner Corp., Chicago, by Arthur J. Welch.*

High-Reduction Actuator



Gear reduction of 100 million:1 is accomplished with a wobble gear arrangement, similar in construction to the conventional swashplate pump mechanism. In this design, motion is transferred from the input to the output gear members by a pair of floating gears. The floating gears are restrained from radial movement but



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4. Quality construction that insures years of trouble-free service.

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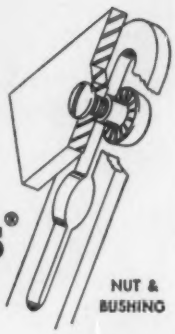

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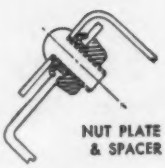

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Here are just a few of the many fastening spots where a Perma-Nut does the job *best.* Each Perma-Nut has from 3 to 4½ clean threads, entirely within the head thickness, to give it ample screw-holding strength. Serrations under the head bite into the surface when the fastener is set, acting as a built-in lockwasher to prevent turning. The head itself takes no more room than a standard hex nut of the same thread size. Nine thread sizes are available, from #3-48 to ¼-28, in steel, brass or aluminum.

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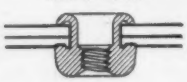

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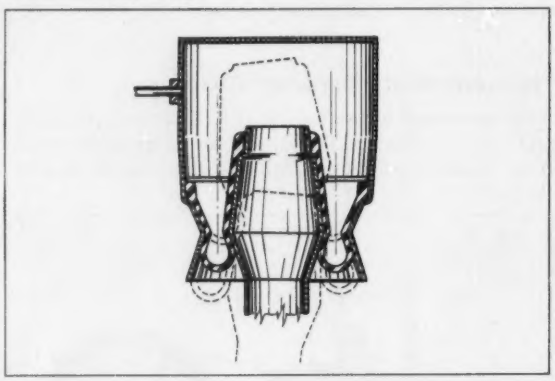
can rotate and tilt to accommodate initiating action of wobble gear. In operation, tooth engagement across the gear elements always maintains a complete power connection from input to output. *Patent* 2,909,944 *assigned to North American Aviation Inc. by George A. Bouvier.*

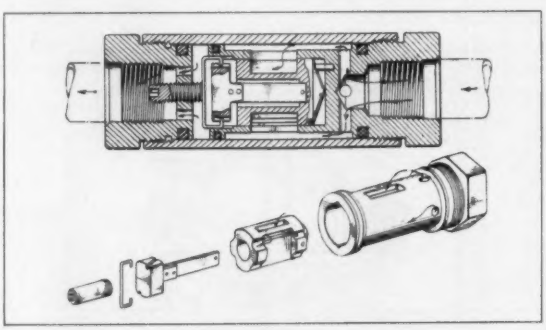
Pneumatic Spring



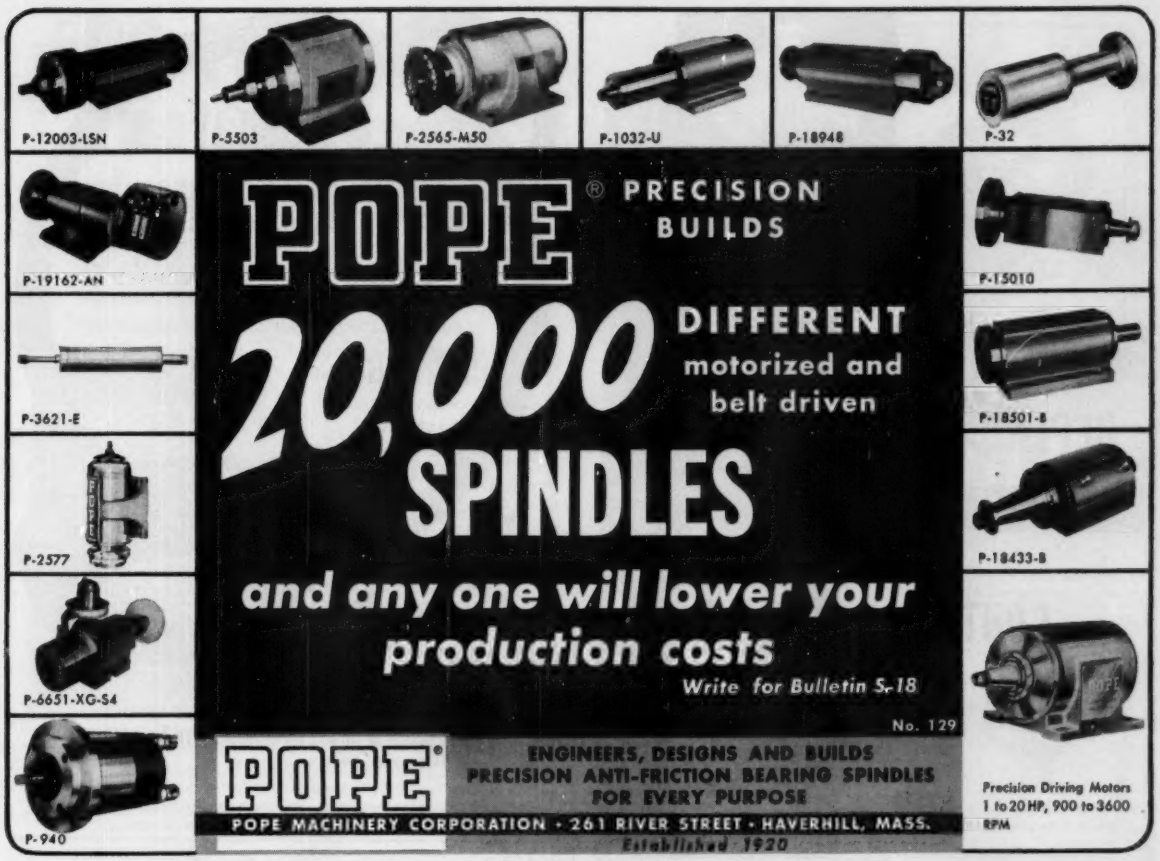
Three-dimensional spring action is achieved between a piston-type member and its cylindrical container with a flexible diaphragm and an air chamber. Axial loads on the piston are accommodated by compression and expansion of high-pressure air volume. Lateral loads are taken up by flexure of the diaphragm. The diaphragm also forms an air-tight closure to the container. *Patent* 2,925,265 *assigned to the Gates Rubber Co., Denver, by Ernest Nassimbene.*

Constant-Pressure Flow Regulator

Torque developed by differential-pressure action rotates a cylindrical vane element to control flow through a hydraulic regulator. Sensitive C-spring, which provides a restoration couple on the cylindrical-shaped vane within its tubular housing, can be preset angularly



with respect to the vane. Overlapping slots in the vane and housing increase or decrease flow-opening, depending upon the angular position of vane. The pressure drop resulting from flow through the opening applies an actuating couple to the vane to change the flow until balance is restored by the C-spring. *Patent* 2,924,236 *assigned to General Dynamics Corp., San Diego, Calif. by Joseph R. Cucuzza.*



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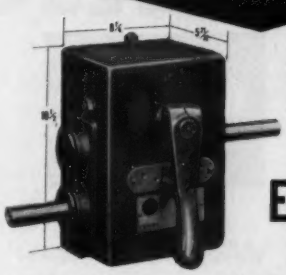

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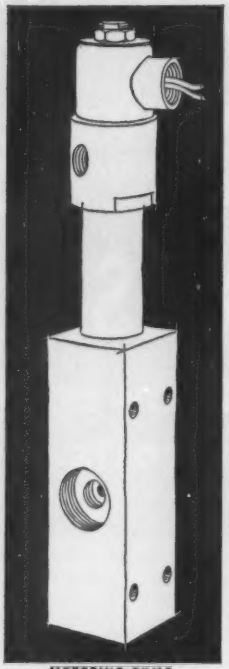

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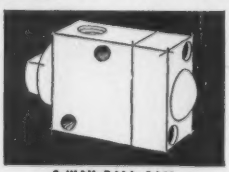

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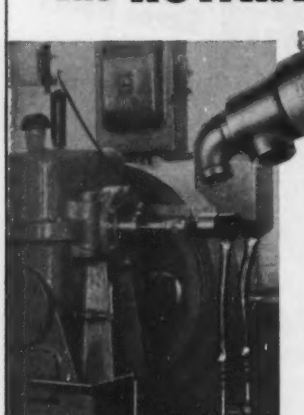

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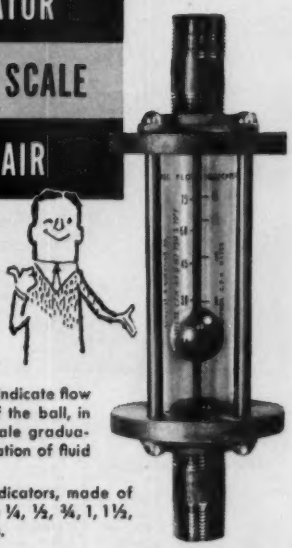

Now, you can obtain approximate measurement of *water flow in gpm* and *air flow in cfm* with SK's Fig. 18123 Ball Flow Indicator.

Note the dual scale, for water and air, on the Flow Indicator in the illustration.

This indicator uses a ball to indicate flow in a pipe line. The position of the ball, in relation to the water or air scale graduations gives approximate indication of fluid rate-of-flow.

SK Fig. 18123 Ball Flow Indicators, made of bronze, are carried in stock in ¼, ½, ¾, 1, 1½, and 2 in. pipe connection sizes.

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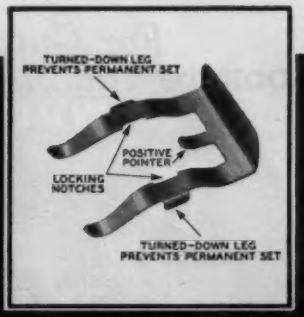

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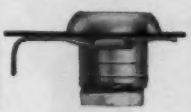
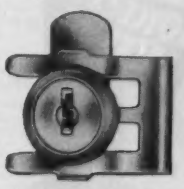
Spring steel clip locks into fastening grooves.

Side view—clip holds lock firmly against metal.



Top view—clip cannot take a permanent set.



Clip in place on Corbin C15258 disc tumbler cam lock. Also available on other cylinder locks.

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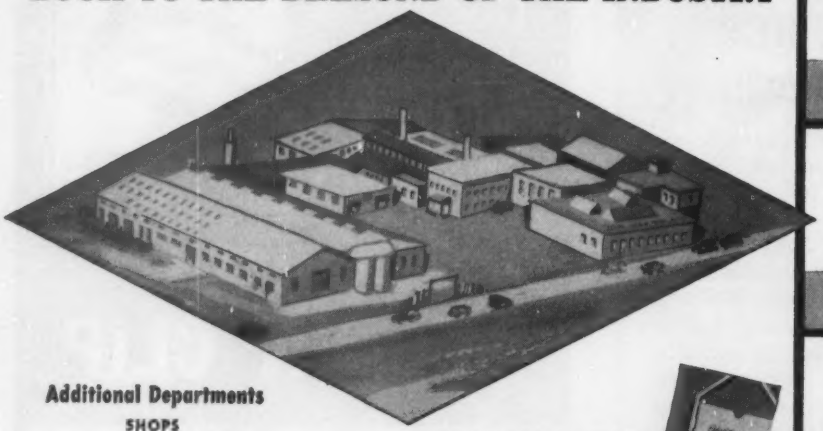

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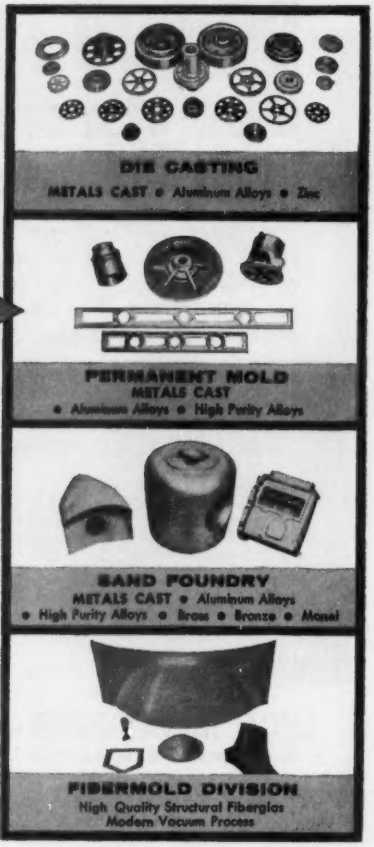

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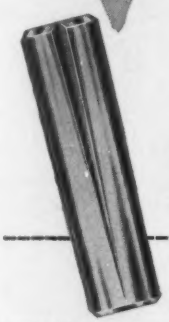

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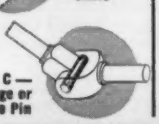

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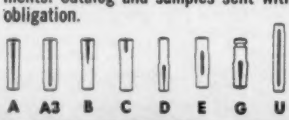

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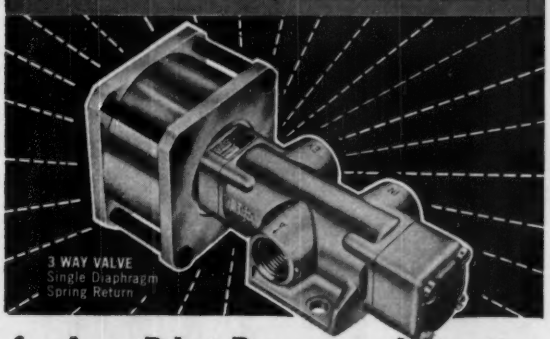

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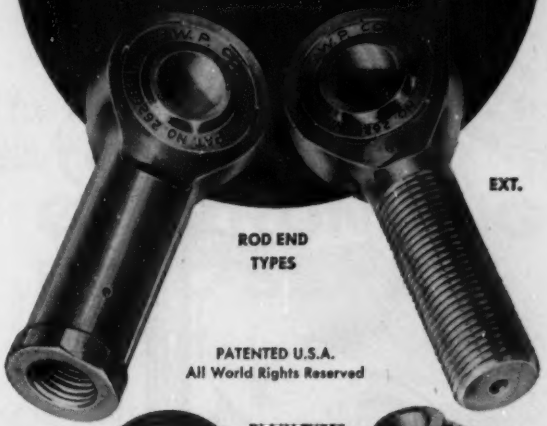

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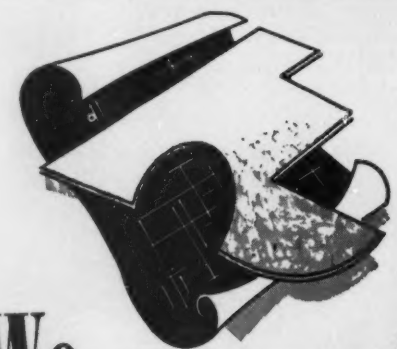

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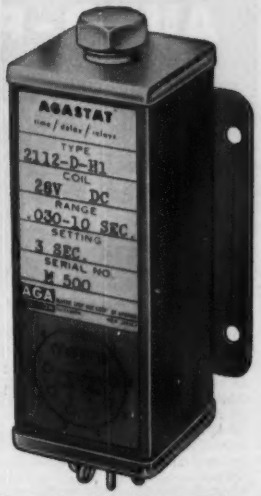

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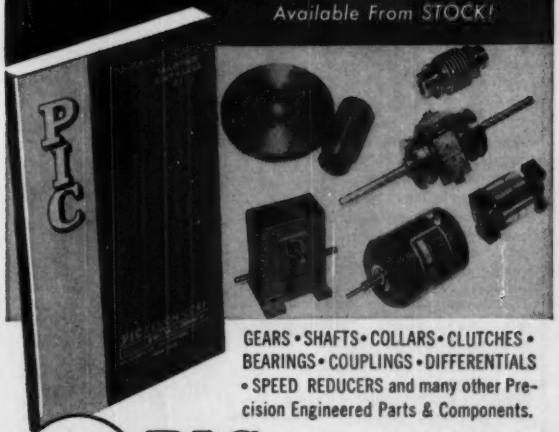

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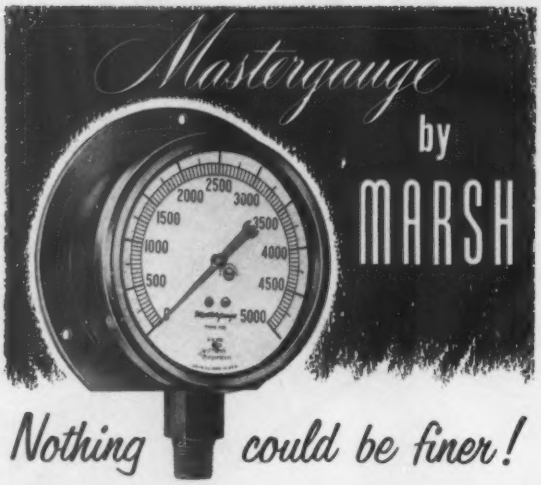
Circle 644 on Page 19



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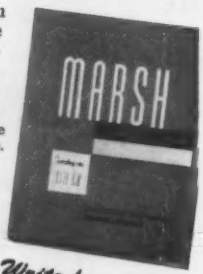

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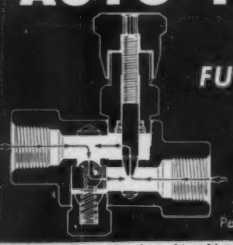

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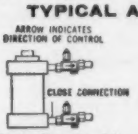

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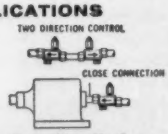

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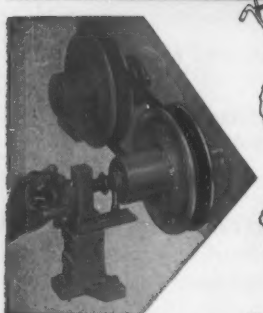

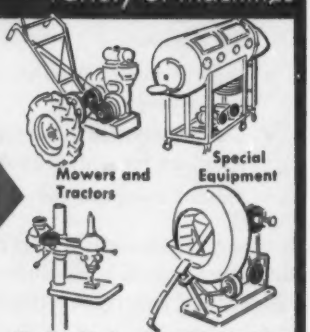

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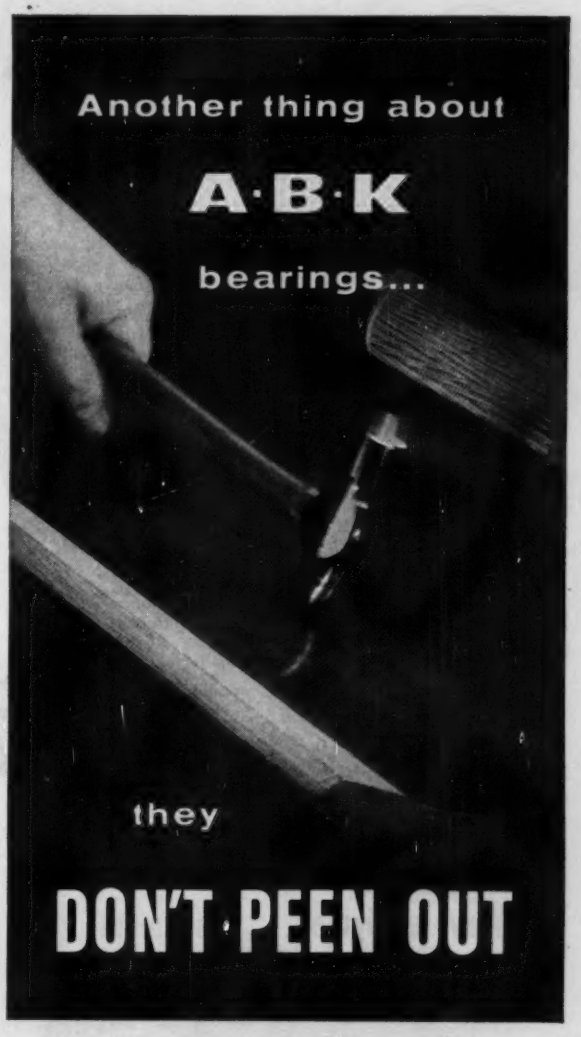

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Simplatrol Stops Miniature Electric Brake Electronic Micrometer Spindle in 7 Millisec.

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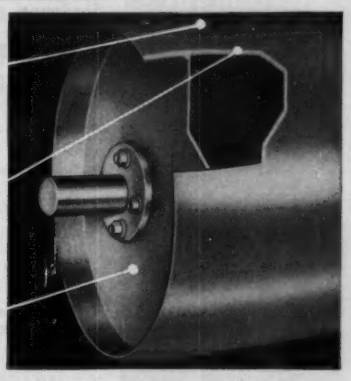

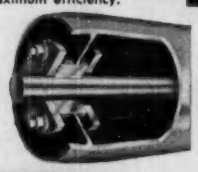

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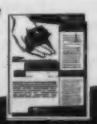

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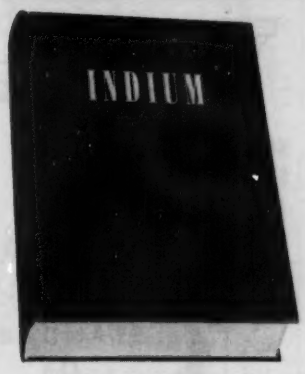

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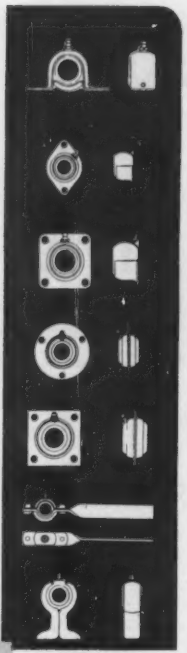

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BPA NEP

backtalk——

—Thermoelectricity Digs In

Gathering material for the article, "Power Without Moving Parts" (Page 24), assistant editor Dick Jacobson went to Pittsburgh to attend a press seminar on new methods of power generation at Westinghouse Research Laboratories. Members of the research staff discussed developments, problems, and outlook for the odd-ball power sources, and in the early afternoon they demonstrated a practical application of thermoelectricity.

The 100-w thermoelectric generator was fired up, a couple of buttons were pushed, and out on a snow-covered construction site, an unmanned shovel broke ground for new research and development facilities. Since completion of the new buildings is scheduled for 1961, it is safe to assume that less exotic construction tools will assist the thermoelectric shovel.

—Distorted Definitions

Almost every convention goer seeks some sort of activity to occupy the hours not spent listening to papers or looking at exhibits. For example, two Raytheon engineers, attending the IRE show in New York last month, took advantage of time between conference sessions to compile a list of electronic terminology. Since these definitions are not likely to find their way into electronics handbooks, we are presenting some of them here:

semiconductor—railway official under five foot two

inertial guidance—permissive parenthood, or leaving well enough alone

countermeasures—Dr. Spock's system, the opposite of inertial guidance

Esaki diode—verses read at a Japanese wake

condenser—designer of midget radios

electronic filter—network for straining harmful tars from cool, smooth microwaves

grid bias—college football game reported by old grad

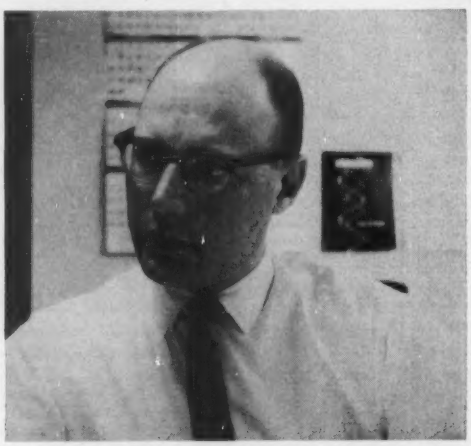
megacycle—small Italian motor scooter

parameter—a rubber ruler

memory tube—a wedding ring

—The Staff of MD (cont.)

Approximately half of Bob Stedfeld's life has been spent in the world of business; half of this time, in turn, has been with MACHINE DESIGN. He joined our staff in 1951 as an assistant editor and was promoted to associate editor in the fall of the following year. Just four years ago, he was named associate managing editor. During his early years here, Bob



was responsible for a variety of our feature departments, and he was the founding editor of the Engineering News section.

Bob studied engineering at Columbia University, received a degree in meteorology at MIT, and earned a B.A. in English at Western Reserve University. He was a fuzzy-cheeked first lieutenant during the war, serving as meteorologist and operations officer. Postwar jobs ranged from part-time type compositor for a check printer to account executive at an advertising agency.

One of Bob's assignments has been to watch over the materials area of design engineering, and he belongs to the American Society for Metals, the American Society of Lubrication Engineers, and the Society of the Plastics Industry. He is also a member of ASME and the Society of Business Magazine Editors.

After hours, from the comparative sublimity of MACHINE DESIGN, Bob turns to science-fiction for leisure reading. He also likes to build missile models, and since he is so handy, gets to do-it-himself when home repairs are needed. For more strenuous exercise, he enjoys a romp with his four children or a spin around the block on his shiny new bicycle.

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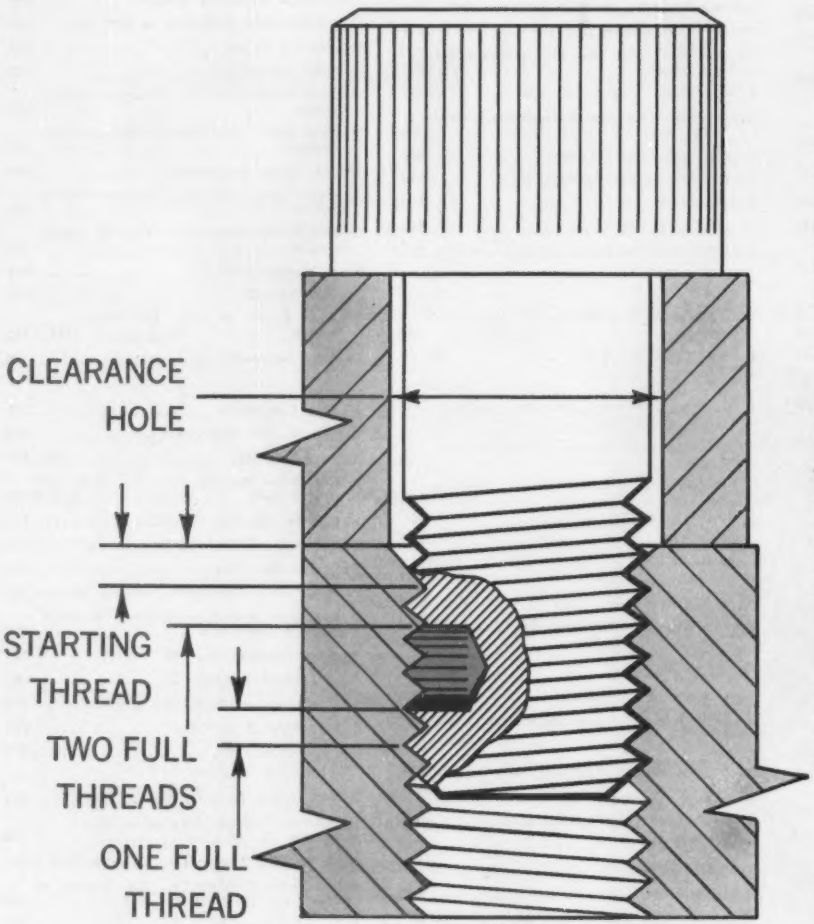

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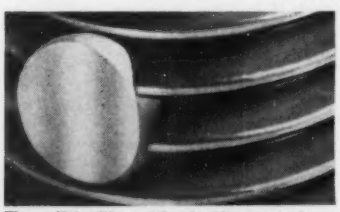

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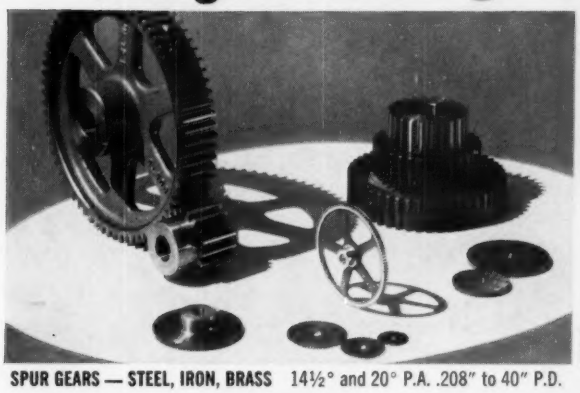

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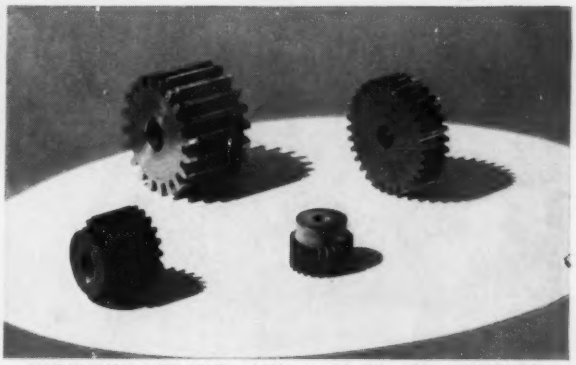

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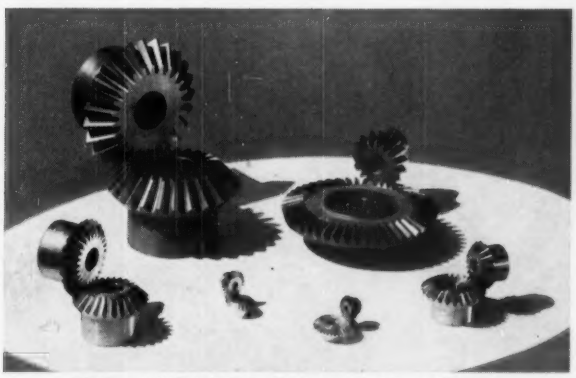

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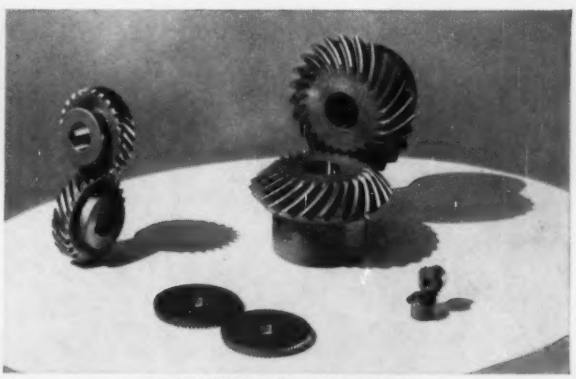

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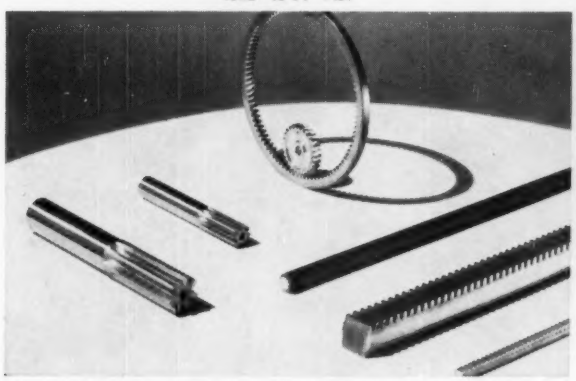

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